



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 9, 2018

Group Chairman's Factual Report

METEOROLOGY

WPR17FA196

Table Of Contents

A.	ACCIDENT	3
B.	METEOROLOGIST	3
C.	DETAILS OF THE INVESTIGATION	3
D.	FACTUAL INFORMATION	3
1.0	Synoptic Situation	3
1.1	Surface Analysis Chart	4
1.2	Upper Air Charts	5
2.0	SPC Products	9
3.0	Surface Observations	9
4.0	Upper Air Data	18
5.0	Satellite Data	20
6.0	Radar Imagery Information	21
7.0	Pilot Reports	22
8.0	SIGMET and CWSU Advisories	23
9.0	AIRMETs	23
10.0	Area Forecast	26
11.0	Terminal Aerodrome Forecast	30
12.0	NWS Area Forecast Discussion	31
13.0	Winds and Temperature Aloft Forecast	33
14.0	Pilot Weather Briefing	33
15.0	Additional Information	33
16.0	Astronomical Data	34
E.	LIST OF ATTACHMENTS	34

A. ACCIDENT

Location: Near Bolinas, California
Date: September 7, 2017
Time: 1400 Pacific daylight time
2100 Coordinated Universal Time (UTC)
Airplane: Cessna 172N, Registration: N737QQ

B. METEOROLOGIST

Paul Suffern
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are Pacific daylight time (PDT) on September 7, 2017, and are based upon the 24-hour clock, where local time is -7 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The final wreckage location was located at latitude 37.937° N, longitude 122.726° W, at an approximate elevation of 400 feet (ft).

D. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction and the Weather Prediction Center, located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 1400 PDT is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart indicated a surface trough¹ located east of the accident site stretching northwest to southeast from north-central California southward to Bakersfield, California. A surface low pressure center with a pressure of 1013-hPa was located in north-central California. A frontal system was located west of the accident site in the eastern Pacific Ocean with the frontal boundaries stretching from western Washington southwestward into the eastern Pacific Ocean. A surface low pressure center with a pressure of 1015-hPa was located in the eastern Pacific Ocean along the frontal boundary. The station models around the accident site depicted air temperatures in the low 60's to low 70's degrees Fahrenheit (°F), dew point temperatures in the low 60's °F with temperature-dew point spreads of 12° F or less, a south to southwest wind of 10 knots or less, and cloudy skies.

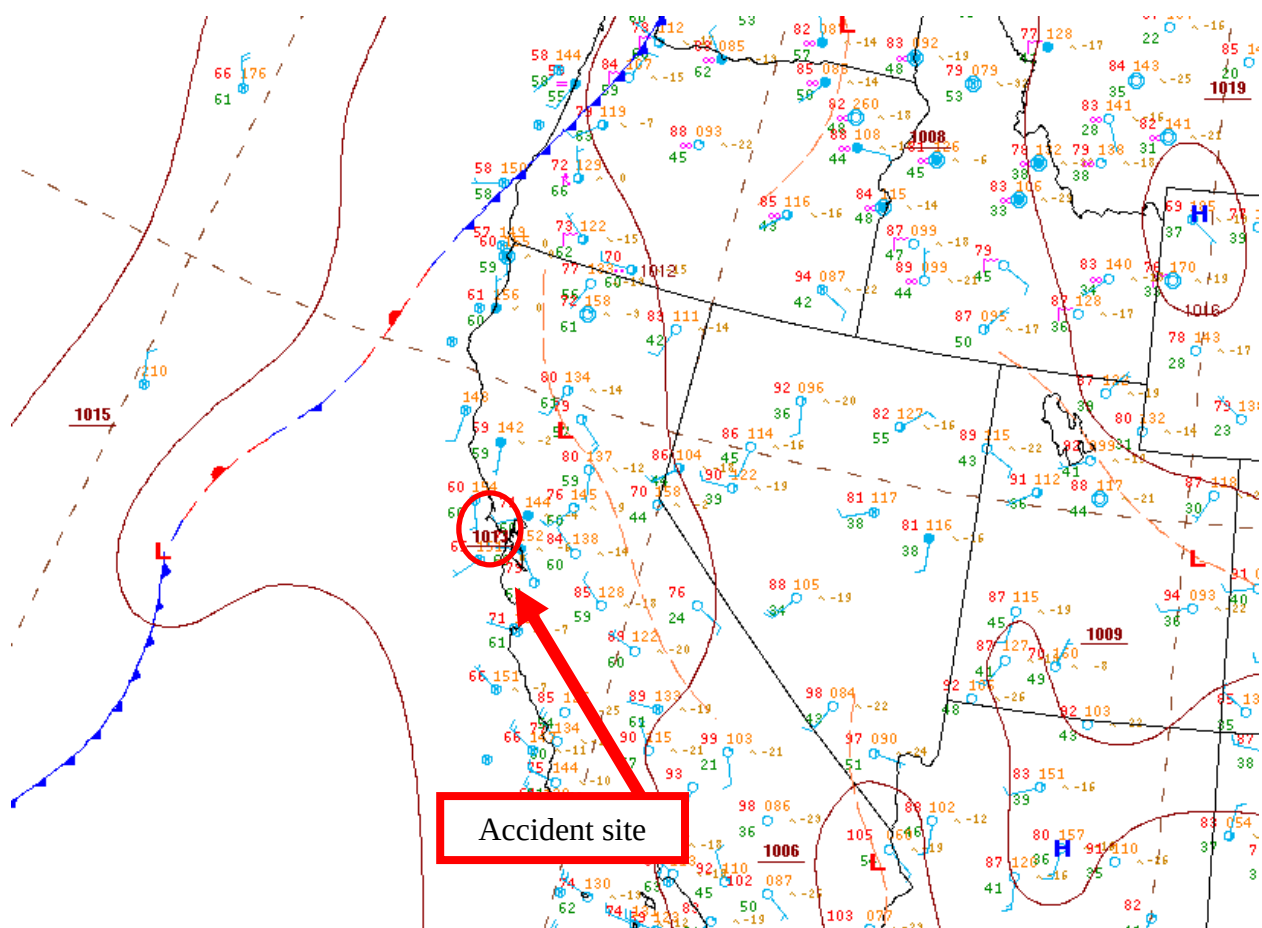


Figure 1 – NWS Surface Analysis Chart for 1400 PDT

¹ Trough – An elongated area of relatively low atmospheric pressure or heights.

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1700 PDT at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6, respectively. There was a mid-level trough located above the accident site (figure 4) at 700-hPa and the mid-level trough was located west of the accident site at 500-hPa (figure 5). Troughs can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. There was a west to southwest onshore² wind of 5 to 25 knots at 925- all the way through 300-hPa.

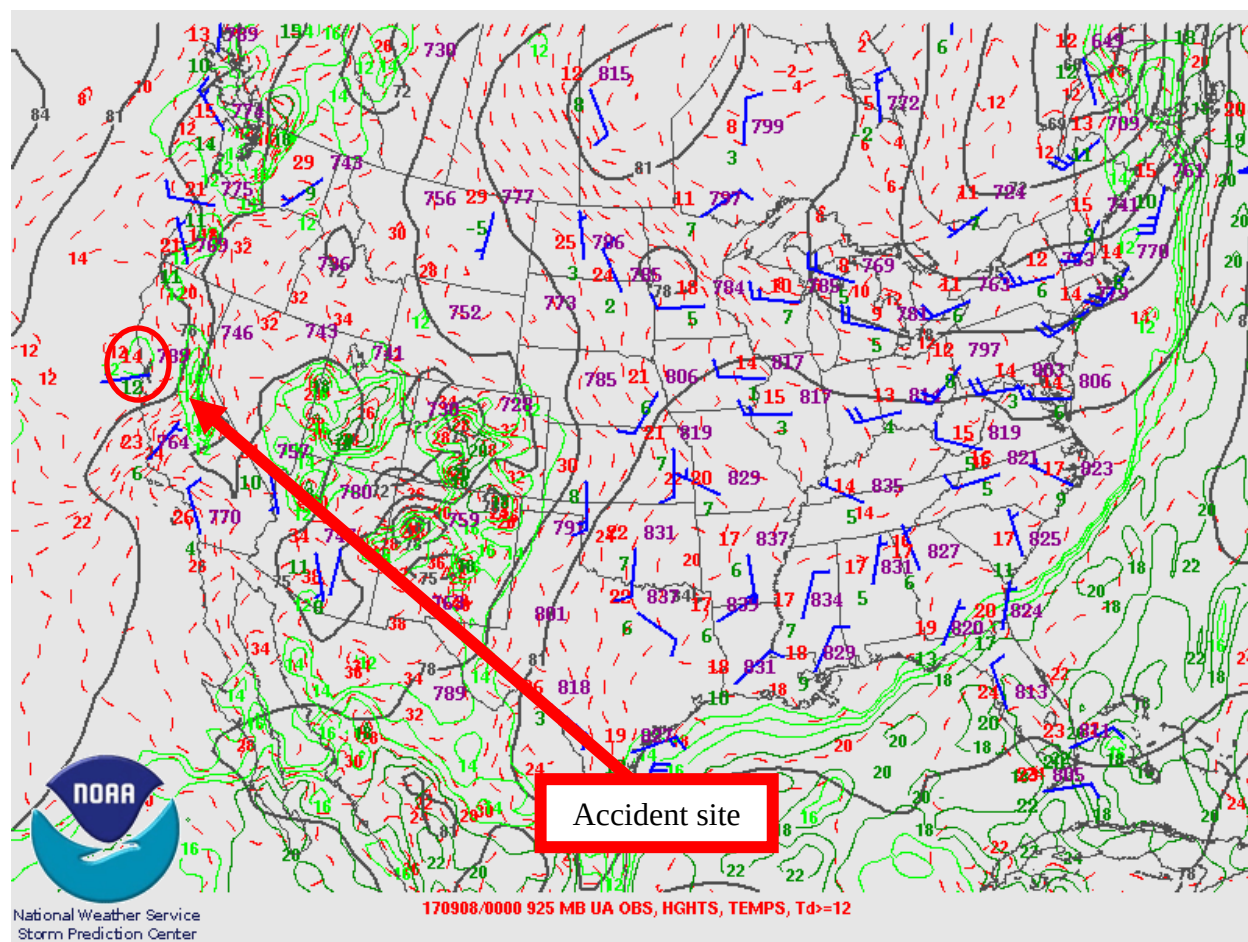


Figure 2 – 925-hPa Constant Pressure Chart for 1700 PDT

² Onshore wind - A wind blowing from water onto land; the wind may be a result of heating differences between land and water or related to synoptic weather patterns.

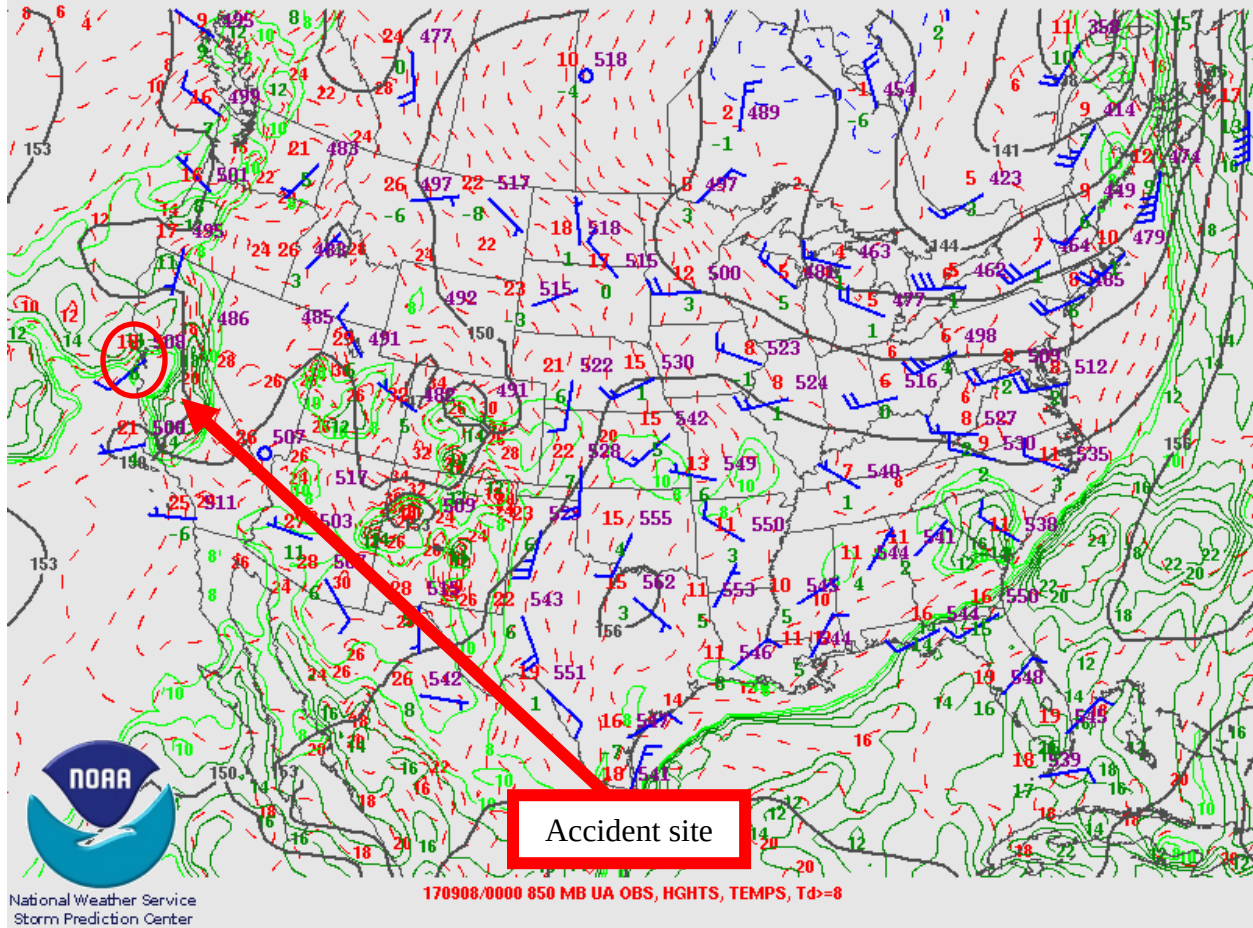


Figure 3 – 850-hPa Constant Pressure Chart for 1700 PDT

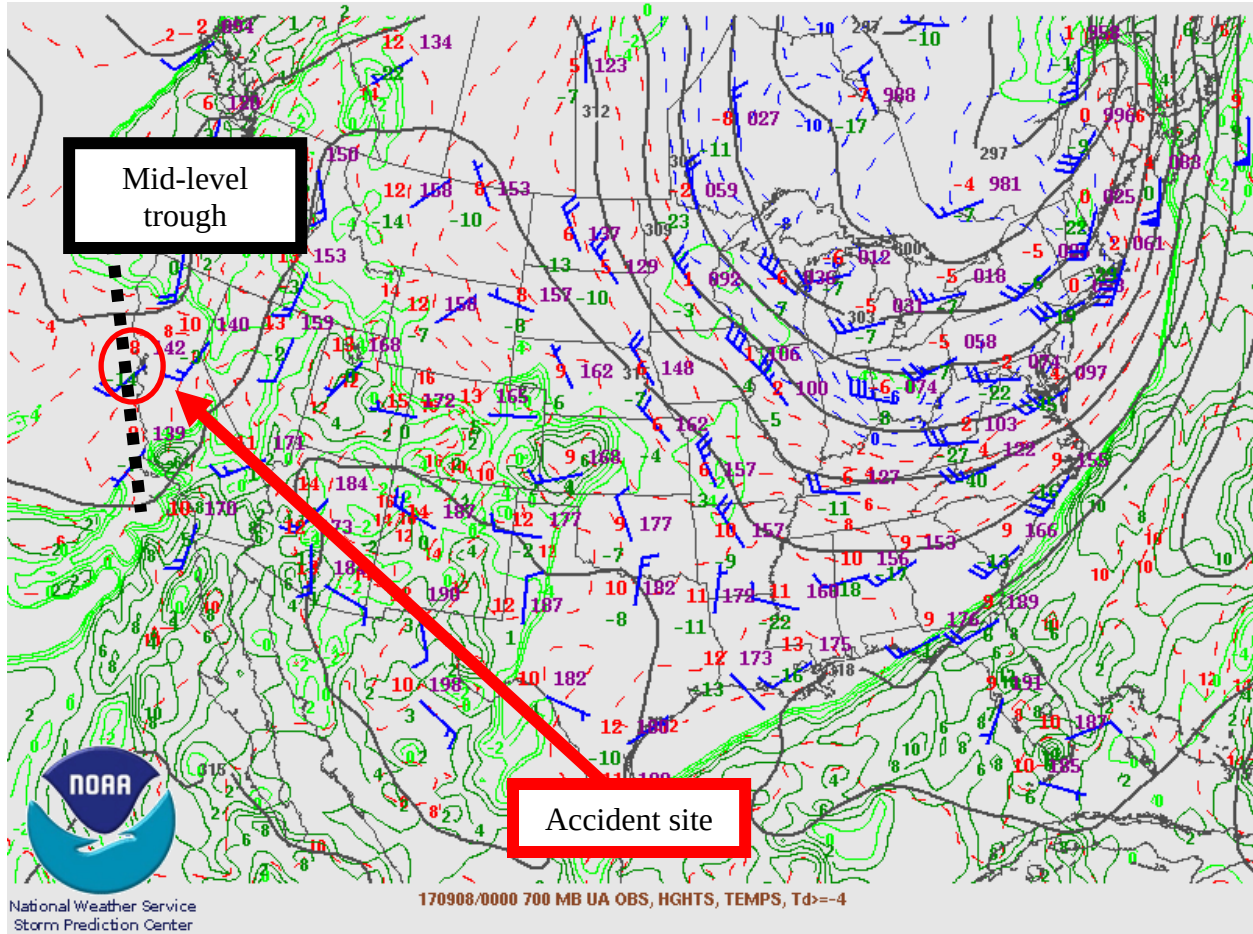


Figure 4 – 700-hPa Constant Pressure Chart for 1700 PDT

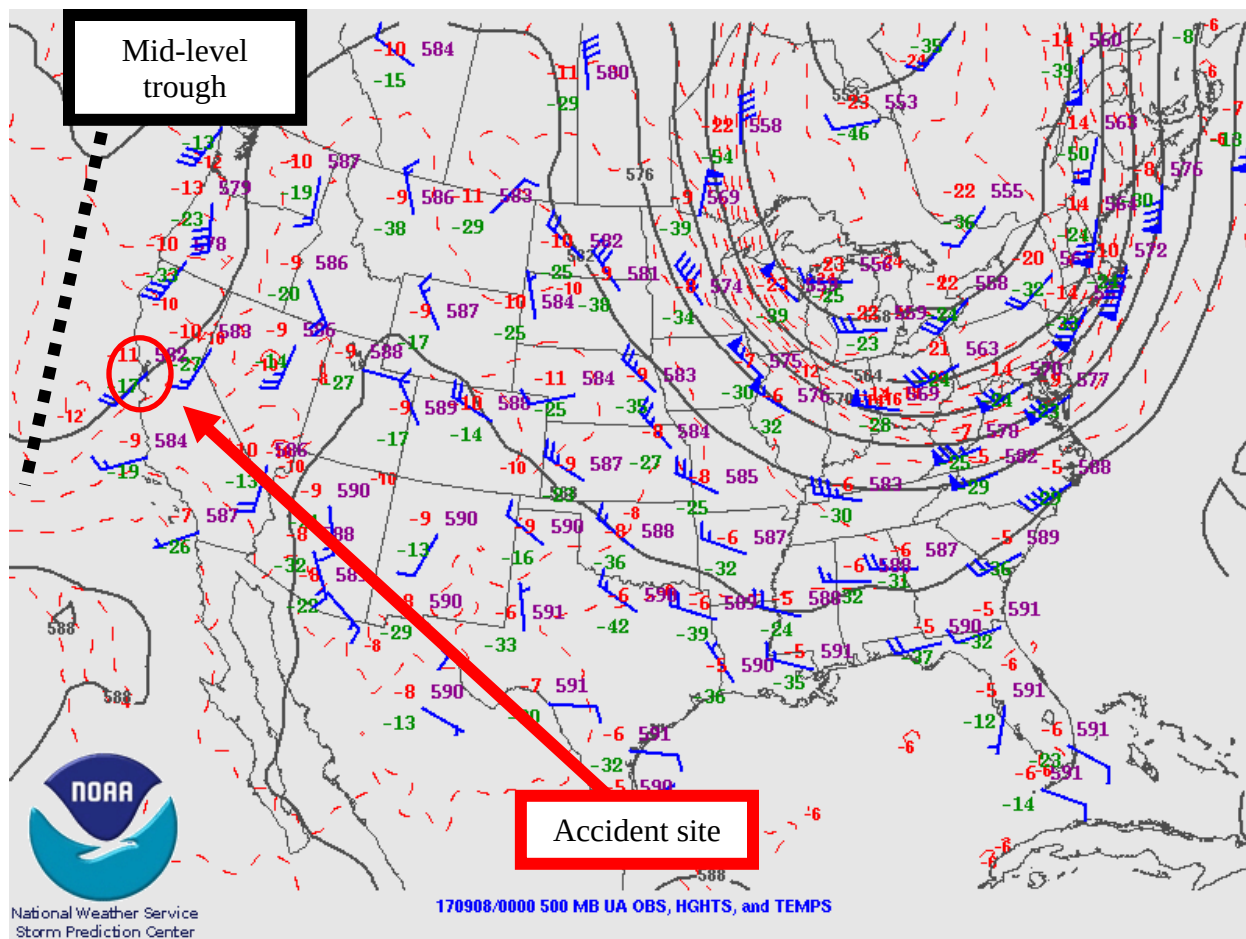


Figure 5 – 500-hPa Constant Pressure Chart for 1700 PDT

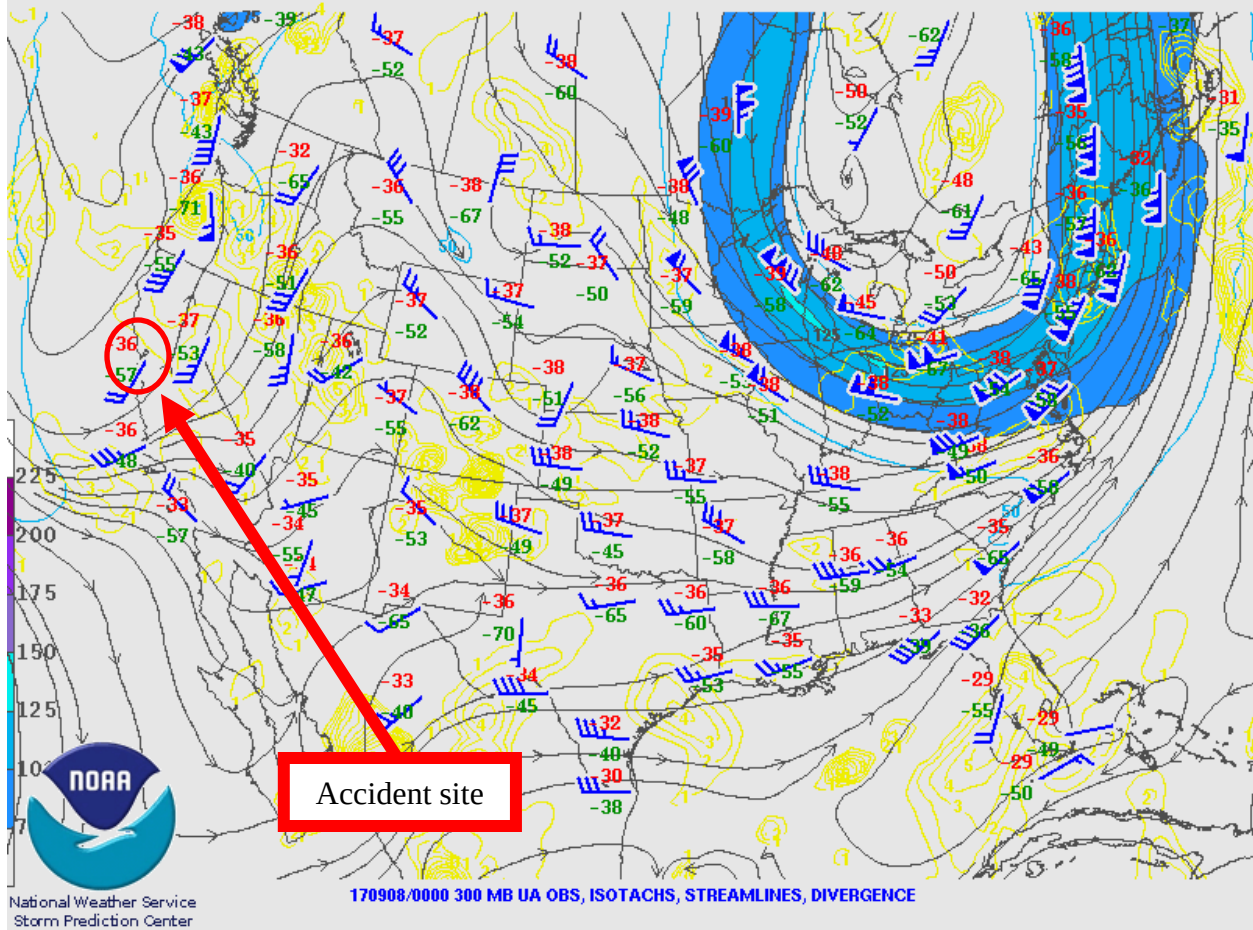


Figure 6 – 300-hPa Constant Pressure Chart for 1700 PDT

2.0 SPC Products

The SPC did not forecast any thunderstorms for the accident site.

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 7 is a sectional chart with the accident site and the official weather reporting locations close to the accident site.

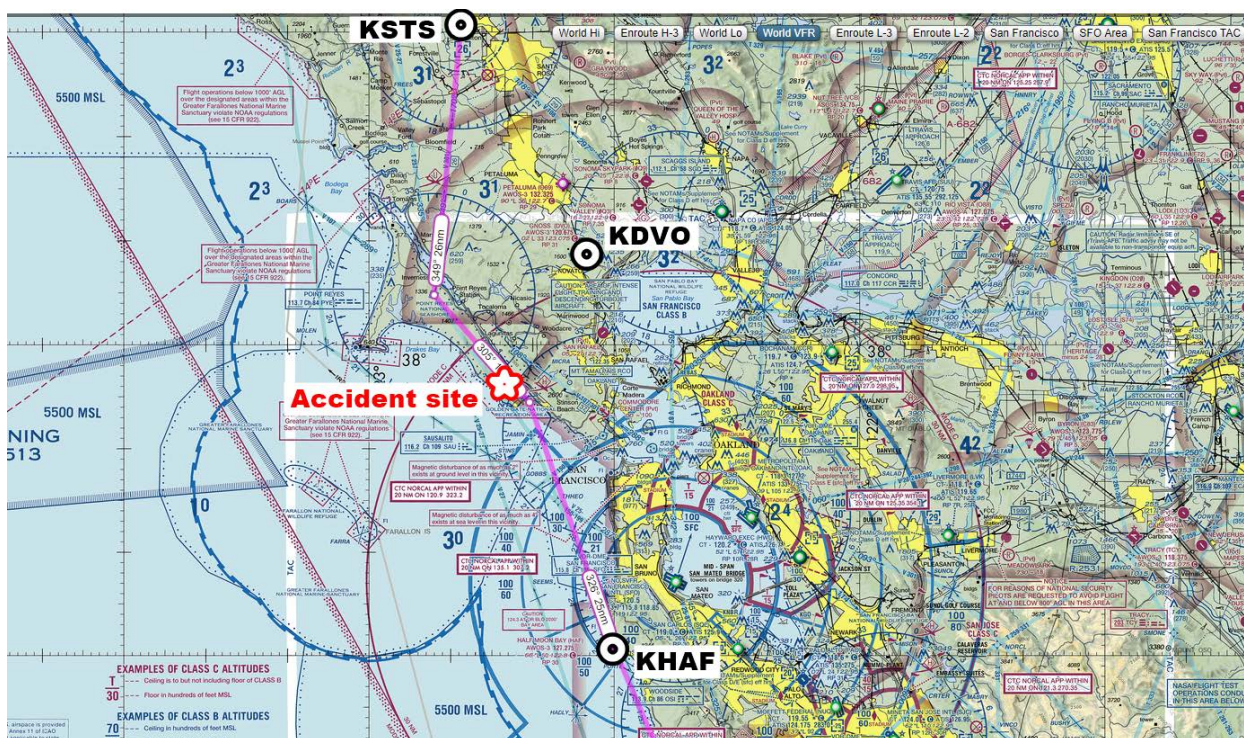


Figure 7 – Sectional chart of accident area with the location of the accident site, surface observation sites, and the proposed route of flight (pink line)

Gross Field Airport (KDVO) had the closest official weather observation point to the accident site, and was located 3 miles north of Novato, California. KDVO had Automated Weather Observing System (AWOS³) whose reports were not supplemented. KDVO was located 15 miles northeast of the accident site, at an elevation of 2 ft, and had a 16° easterly magnetic variation⁴ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:⁵

[1155 PDT] METAR KDVO 071855Z AUTO 24003KT 10SM BKN016 OVC026 20/17
A3000 RMK AO2=

[1215 PDT] METAR KDVO 071915Z AUTO 00000KT 10SM FEW016 OVC025 20/17
A3000 RMK AO2=

[1235 PDT] METAR KDVO 071935Z AUTO VRB04KT 10SM FEW017 OVC025 21/17
A3000 RMK AO2=

³ AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to twelve thousand feet, and altimeter setting.

⁴ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1995, latest measurement taken from <http://airnav.com/airport/KDVO>

⁵ Bolded sections in this report highlight information that directly reference the weather conditions that affected the accident location around the accident time.

[1255 PDT] METAR KDVO 071955Z AUTO 24004KT 10SM OVC025 21/16 A2999 RMK AO2=

[1315 PDT] METAR KDVO 072015Z AUTO 25007KT 10SM OVC027 21/16 A2999 RMK AO2=

[1335 PDT] METAR KDVO 072035Z AUTO 24007KT 200V260 10SM OVC027 21/16 A2999 RMK AO2=

[1355 PDT] METAR KDVO 072055Z AUTO 24007KT 10SM OVC026 21/16 A2999 RMK AO2=

ACCIDENT TIME 1400 PDT

[1415 PDT] METAR KDVO 072115Z AUTO 25004KT 10SM OVC027 21/16 A2998 RMK AO2=

[1435 PDT] METAR KDVO 072135Z AUTO 22007KT 10SM OVC026 21/16 A2998 RMK AO2=

[1455 PDT] METAR KDVO 072155Z AUTO 21004KT 10SM OVC025 21/16 A2997 RMK AO2=

[1515 PDT] METAR KDVO 072215Z AUTO 23005KT 10SM OVC027 21/16 A2996 RMK AO2=

KDVO weather at 1335 PDT, automated, wind from 240° at 7 knots, wind direction varying between 200° and 260°, 10 miles or greater visibility, overcast ceiling at 2,700 ft above ground level (agl), temperature of 21° Celsius (C), dew point temperature of 16° C, and an altimeter setting of 29.99 inches of mercury. Remarks, station with a precipitation discriminator.

KDVO weather at 1355 PDT, automated, wind from 240° at 7 knots, 10 miles or greater visibility, overcast ceiling at 2,600 ft agl, temperature of 21° C, dew point temperature of 16° C, and an altimeter setting of 29.99 inches of mercury. Remarks, station with a precipitation discriminator.

KDVO weather at 1415 PDT, automated, wind from 250° at 4 knots, 10 miles or greater visibility, overcast ceiling at 2,700 ft agl, temperature of 21° C, dew point temperature of 16° C, and an altimeter setting of 29.98 inches of mercury. Remarks, station with a precipitation discriminator.

KDVO weather at 1435 PDT, automated, wind from 220° at 7 knots, 10 miles or greater visibility, overcast ceiling at 2,600 ft agl, temperature of 21° C, dew point temperature of 16° C, and an altimeter setting of 29.98 inches of mercury. Remarks, station with a precipitation discriminator.

Half Moon Bay Airport (KHAF) was the closest official weather station to the accident site along the coastal region of California and was located 5 miles northwest of Half Moon Bay, California. KHAF had an AWOS whose reports were not supplemented. KHAF was located 28 miles south-southeast of the accident site, at an elevation of 66 ft, and had a 15° easterly magnetic variation⁶ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:⁷

[1155 PDT] METAR KHAF 071855Z AUTO 19008KT 7SM FEW006 BKN017 OVC036
19/ A2998 RMK AO2=

[1215 PDT] METAR KHAF 071915Z AUTO 19006KT 7SM SCT017 OVC036 19/ A2998
RMK AO2=

[1235 PDT] METAR KHAF 071935Z AUTO 20006KT 7SM BKN017 OVC036 19/ A2998
RMK AO2=

[1255 PDT] METAR KHAF 071955Z AUTO 21006KT 7SM SCT013 SCT018 OVC034
19/ A2998 RMK AO2=

[1315 PDT] METAR KHAF 072015Z AUTO 19006KT 8SM BKN016 OVC034 19/ A2998
RMK AO2=

**[1335 PDT] METAR KHAF 072035Z AUTO 22005KT 7SM FEW016 OVC034 19/ A2998
RMK AO2=**

**[1355 PDT] METAR KHAF 072055Z AUTO 23006KT 7SM OVC034 19/ A2997 RMK
AO2=**

ACCIDENT TIME 1400 PDT

**[1415 PDT] METAR KHAF 072115Z AUTO 21007KT 7SM OVC034 19/ A2997 RMK
AO2=**

**[1435 PDT] METAR KHAF 072135Z AUTO 21005KT 7SM SCT018 OVC034 19/ A2996
RMK AO2=**

[1455 PDT] METAR KHAF 072155Z AUTO 22005KT 7SM FEW016 OVC034 19/ A2996
RMK AO2=

[1515 PDT] METAR KHAF 072215Z AUTO 24005KT 7SM OVC034 19/ A2995 RMK
AO2=

⁶ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1995, latest measurement taken from <http://airnav.com/airport/KHAF>

⁷ Dew point temperature was missing from KHAF METARs for an unknown reason. In addition, no “\$” for maintenance needed on the system was reported.

KHAF weather at 1335 PDT, automated, wind from 220° at 5 knots, 7 miles visibility, few clouds at 1,600 ft agl, overcast ceiling at 3,400 ft agl, temperature of 19° C, and an altimeter setting of 29.98 inches of mercury. Remarks, station with a precipitation discriminator.

KHAF weather at 1355 PDT, automated, wind from 230° at 6 knots, 7 miles visibility, overcast ceiling at 3,400 ft agl, temperature of 19° C, and an altimeter setting of 29.97 inches of mercury. Remarks, station with a precipitation discriminator.

KHAF weather at 1415 PDT, automated, wind from 210° at 7 knots, 7 miles visibility, overcast ceiling at 3,400 ft agl, temperature of 19° C, and an altimeter setting of 29.97 inches of mercury. Remarks, station with a precipitation discriminator.

KHAF weather at 1435 PDT, automated, wind from 210° at 5 knots, 7 miles visibility, scattered clouds at 1,800 ft agl, overcast ceiling at 3,400 ft agl, temperature of 19° C, and an altimeter setting of 29.96 inches of mercury. Remarks, station with a precipitation discriminator.

Charles M. Schulz/Sonoma County Airport (KSTS) was the intended destination airport and was located 6 miles northwest of Santa Rosa, California. KSTS had Automated Surface Observing System (ASOS⁸) whose reports were supplemented by air traffic control. KSTS was located 35 miles north-northwest of the accident site, at an elevation of 129 ft, and had a 16° easterly magnetic variation⁹ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:

[0922 PDT] SPECI KSTS 071622Z 15004KT 2 1/2SM -RA BR BKN007 OVC014 18/17
A2996 RMK AO2 RAB01 P0001 T01780172=

[0953 PDT] METAR KSTS 071653Z 15003KT 2 1/2SM -RA BR BKN007 OVC021 18/18
A2997 RMK AO2 RAB01 SLP142 P0001 T01830178=

[1008 PDT] SPECI KSTS 071708Z 15007KT 7SM BKN007 OVC021 18/17 A2997
RMK AO2 RAE01 P0000 T01830172=

[1053 PDT] METAR KSTS 071753Z 19007KT 4SM BR BKN010 OVC037 19/17 A2998
RMK AO2 RAE01 SLP144 P0000 60001 T01890172 10189 20178 53010=

[1153 PDT] METAR KSTS 071853Z 22005KT 10SM BKN012 OVC037 20/17 A2998
RMK AO2 SLP145 P0001 T02000167=

**[1253 PDT] METAR KSTS 071953Z 18005KT 10SM BKN012 OVC039 20/17 A2997
RMK AO2 RAB07E17 SLP143 P0000 T02000167=**

[1353 PDT] METAR KSTS 072053Z 19005KT 9SM BKN013 OVC028 19/17 A2997

⁸ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

⁹ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1985, latest measurement taken from <http://airnav.com/airport/KSTS>

AO2 RAB14E45 SLP142 P0000 60001 T01940172 58002=

ACCIDENT TIME 1400 PDT

**[1453 PDT] METAR KSTS 072153Z 17003KT 7SM BKN013 OVC028 20/17 A2996
RMK AO2 SLP137 T02000167=**

**[1500 PDT] SPECI KSTS 072200Z 20004KT 9SM OVC031 20/17 A2996 RMK AO2
T02000167=**

**[1507 PDT] SPECI KSTS 072207Z 20003KT 7SM BKN013 OVC028 20/17 A2996
RMK AO2 T02000167=**

**[1553 PDT] METAR KSTS 072253Z 20005KT 7SM BKN013 OVC028 21/17 A2994
RMK AO2 SLP132 T02060167=**

KSTS weather at 1253 PDT, wind from 180° at 5 knots, 10 miles or greater visibility, broken ceiling at 1,200 ft agl, overcast skies at 3,900 ft agl, temperature of 20° C, dew point temperature of 17° C, and an altimeter setting of 29.97 inches of mercury. Remarks, station with a precipitation discriminator, rain began at 1207 PDT, rain ended at 1217 PDT, sea level pressure 1014.3 hPa, a trace of precipitation since 1153 PDT, temperature 20.0° C, dew point temperature 16.7° C.

KSTS weather at 1353 PDT, wind from 190° at 5 knots, 9 miles visibility, broken ceiling at 1,300 ft agl, overcast skies at 2,800 ft agl, temperature of 19° C, dew point temperature of 17° C, and an altimeter setting of 29.97 inches of mercury. Remarks, station with a precipitation discriminator, rain began at 1314 PDT, rain ended at 1345 PDT, sea level pressure 1014.2 hPa, a trace of precipitation since 1253 PDT, 6-hourly precipitation of 0.01 inches, temperature 19.4° C, dew point temperature 17.2° C, 3-hourly pressure decrease of 0.2 hPa.

KSTS weather at 1453 PDT, wind from 170° at 3 knots, 7 miles visibility, broken ceiling at 1,300 ft agl, overcast skies at 2,800 ft agl, temperature of 20° C, dew point temperature of 17° C, and an altimeter setting of 29.96 inches of mercury. Remarks, station with a precipitation discriminator, sea level pressure 1013.7 hPa, temperature 20.0° C, dew point temperature 16.7° C.

KSTS weather at 1500 PDT, wind from 200° at 4 knots, 9 miles visibility, overcast ceiling at 3,100 ft agl, temperature of 20° C, dew point temperature of 17° C, and an altimeter setting of 29.96 inches of mercury. Remarks, station with a precipitation discriminator, temperature 20.0° C, dew point temperature 16.7° C.



Figure 8 – Terrain map of the accident area with the location of the accident site and unofficial surface observation sites

WOODACRE (WDAC1) was a Remote Automatic Weather Station (RAWS) and was the closest non-official surface observation site to the accident site located 5 miles east-northeast of the accident site at an elevation of 1,400 ft (figure 8). Figure 9 contains the observations from WDAC1 surrounding the accident time:

# STATION: WDAC1												
# STATION NAME: WOODACRE												
# LATITUDE: 37.990556												
# LONGITUDE: -122.644722												
# ELEVATION [ft]: 1400												
# STATE: CA												
Station_ID	Date_Time	air_temp_set Fahrenheit	relative_humidity %	wind_speed Miles/hour	wind_direction Degrees	wind_gust Miles/hour	solar_radiation W/m**2	precip_accum Inches	peak_wind_speed Miles/hour	peak_wind_direction Degrees	dew_point_temperature_set_1d Fahrenheit	
WDAC1	09/06/2017 21:51 PDT	60.01	100	4	209	11.01	0	0.01	11.01	233	60.01	
WDAC1	09/06/2017 22:51 PDT	60.01	100	4	215	11.01	0	0.01	11.01	150	60.01	
WDAC1	09/06/2017 23:51 PDT	60.01	100	5.99	202	14	0	0.01	14	169	60.01	
WDAC1	09/07/2017 00:51 PDT	60.01	100	5.99	188	14	0	0.02	14	139	60.01	
WDAC1	09/07/2017 01:51 PDT	59	100	4	225	11.01	0	0.02	11.01	149	59	
WDAC1	09/07/2017 02:51 PDT	59	100	4.99	220	13	0	0.02	13	203	59	
WDAC1	09/07/2017 03:51 PDT	59	100	4	228	13	0	0.02	13	162	59	
WDAC1	09/07/2017 04:51 PDT	59	100	4.99	213	14	0	0.03	14	177	59	
WDAC1	09/07/2017 05:51 PDT	59	100	7	235	14.99	0	0.05	14.99	256	59	
WDAC1	09/07/2017 06:51 PDT	59	100	8.01	229	17	0	0.05	17	243	59	
WDAC1	09/07/2017 07:51 PDT	59	100	7	226	14.99	7	0.07	14.99	234	59	
WDAC1	09/07/2017 08:51 PDT	59	100	4.99	209	14.99	27	0.07	14.99	243	59	
WDAC1	09/07/2017 09:51 PDT	60.01	100	4.99	217	14	48	0.07	14	265	60.01	
WDAC1	09/07/2017 10:51 PDT	60.01	100	4.99	217	14	68	0.07	14	230	60.01	
WDAC1	09/07/2017 11:51 PDT	61	100	4	236	10	99	0.07	10	243	61	
WDAC1	09/07/2017 12:51 PDT	61	100	4.99	227	10	102	0.07	10	240	61	
WDAC1	09/07/2017 13:51 PDT	61	99	4	249	12.01	89	0.07	12.01	238	60.71	
WDAC1	09/07/2017 14:51 PDT	61	97	4	232	8.01	82	0.07	8.01	274	60.13	
WDAC1	09/07/2017 15:51 PDT	62.01	98	4.99	282	7	83	0.07	7	272	61.43	
WDAC1	09/07/2017 16:51 PDT	62.01	97	4.99	266	7	76	0.07	7	276	61.14	
WDAC1	09/07/2017 17:51 PDT	63	96	4	280	7	124	0.08	7	281	61.83	
WDAC1	09/07/2017 18:51 PDT	62.01	95	5.99	267	10	126	0.08	10	280	60.55	
WDAC1	09/07/2017 19:51 PDT	59	100	11.01	282	15.99	26	0.08	15.99	310	59	
WDAC1	09/07/2017 20:51 PDT	59	100	7	290	17	0	0.08	17	288	59	

Figure 9 – List of observations from WDAC1 surrounding the accident time

WDAC1 weather at 1351 PDT was reported as, wind from 249° at 4 miles-per-hour (mph) with gusts to 12.01 mph, temperature of 61° F, a dew point temperature of 60.71° F, and a relative humidity of 99 percent.

WDAC1 weather at 1451 PDT was reported as, wind from 232° at 4 mph with gusts to 8.01 mph, temperature of 61° F, a dew point temperature of 60.13° F, and a relative humidity of 97 percent.

WDAC1 weather at 1551 PDT was reported as, wind from 282° at 4.99 mph with gusts to 7 mph, temperature of 62.01° F, a dew point temperature of 61.43° F, and a relative humidity of 98 percent.

BARNABY (BBEC1) was a RAWS and was the next closest non-official surface observation site to the accident site located 6 miles north-northeast of the accident site at an elevation of 810 ft (figure 8). Figure 10 contains the observations from BBEC1 surrounding the accident time:

# STATION: BBEC1												
# STATION NAME: BARNABY												
# LATITUDE: 38.028056												
# LONGITUDE: -122.702222												
# ELEVATION [ft]: 810												
# STATE: CA												
Station_ID	Date_Time	air_temp_set	relative_humidity_s	wind_speed_s	wind_direction	wind_gust_s	solar_radiation	precip_accum_s	peak_wind_speed_s	peak_wind_direction	dew_point_temperature_set	dew_point_temperature_set_id
		Fahrenheit	%	Miles/hour	Degrees	Miles/hour	W/m**2	Inches	Miles/hour	Degrees	Fahrenheit	
BBEC1	09/06/2017 19:11 PDT	62.01		92	4	201	14	36	76.79	14	216	59.64
BBEC1	09/06/2017 20:11 PDT	62.01		93	4.99	220	12.01	4	76.79	12.01	234	59.95
BBEC1	09/06/2017 21:11 PDT	62.01		96	4	223	8.01	0	76.79	8.01	167	60.85
BBEC1	09/06/2017 22:11 PDT	62.01		98	3	216	8.01	0	76.79	8.01	245	61.43
BBEC1	09/06/2017 23:11 PDT	62.01		98	2.01	187	11.01	0	76.79	11.01	213	61.43
BBEC1	09/07/2017 00:11 PDT	62.01		98	2.01	143	10	0	76.79	10	143	61.43
BBEC1	09/07/2017 01:11 PDT	62.01		99	2.01	149	8.01	0	76.8	8.01	197	61.72
BBEC1	09/07/2017 02:11 PDT	61		99	3	173	10	0	76.81	10	228	60.71
BBEC1	09/07/2017 03:11 PDT	61		97	1.01	197	11.01	0	76.81	11.01	248	60.13
BBEC1	09/07/2017 04:11 PDT	61		97	4	190	13	0	76.81	13	202	60.13
BBEC1	09/07/2017 05:11 PDT	61		97	2.01	170	10	0	76.81	10	190	60.13
BBEC1	09/07/2017 06:11 PDT	61		98	4	212	12.01	0	76.82	12.01	204	60.43
BBEC1	09/07/2017 07:11 PDT	61		98	4	202	14.99	1	76.83	14.99	163	60.43
BBEC1	09/07/2017 08:11 PDT	62.01		96	4	195	11.01	15	76.83	11.01	195	60.85
BBEC1	09/07/2017 09:11 PDT	62.01		95	4	180	13	34	76.83	13	239	60.55
BBEC1	09/07/2017 10:11 PDT	62.01		96	3	203	10	56	76.84	10	226	60.85
BBEC1	09/07/2017 11:11 PDT	63		94	3	201	8.01	89	76.84	8.01	218	61.23
BBEC1	09/07/2017 12:11 PDT	64		92	1.01	162	5.99	114	76.84	5.99	242	61.61
BBEC1	09/07/2017 13:11 PDT	64		92	2.01	200	7	127	76.84	7	235	61.61
BBEC1	09/07/2017 14:11 PDT	64.99		88	2.01	180	7	180	76.84	7	201	61.32
BBEC1	09/07/2017 15:11 PDT	64		90	4.99	268	8.01	113	76.84	8.01	277	60.99
BBEC1	09/07/2017 16:11 PDT	66		84	2.01	246	8.01	177	76.84	8.01	228	60.99
BBEC1	09/07/2017 17:11 PDT	66		84	1.01	206	8.01	131	76.84	8.01	246	60.99
BBEC1	09/07/2017 18:11 PDT	66.99		78	4.99	266	8.99	221	76.84	8.99	248	59.86

Figure 10 – List of observations from BBEC1 surrounding the accident time

BBEC1 weather at 1311 PDT was reported as, wind from 200° at 2.01 mph with gusts to 7 mph, temperature of 64° F, a dew point temperature of 61.61° F, and a relative humidity of 92 percent.

BBEC1 weather at 1411 PDT was reported as, wind from 180° at 2.01 mph with gusts to 7 mph, temperature of 64.99° F, a dew point temperature of 61.32° F, and a relative humidity of 88 percent.

BBEC1 weather at 1511 PDT was reported as, wind from 268° at 4.99 mph with gusts to 8.01 mph, temperature of 64° F, a dew point temperature of 60.99° F, and a relative humidity of 90 percent.

EW9939 Mill Valley (E9939) was an Automatic Position Reporting System as a WX NET/Citizen Weather Observer Program (APRSWXNET/CWOP) mesonet station and was the next closest non-official surface observation site to the accident site. E9939 was located 6 miles east-southeast of the accident site at an elevation of 1,824 ft (figure 8). Figure 11 contains the E9939 observations surrounding the accident time:

# STATION: E9939											
# STATION NAME: EW9939 Mill Valley											
# LATITUDE: 37.91683											
# LONGITUDE: -122.59383											
# ELEVATION (ft): 1824											
# STATE: CA											
Station_ID	Date_Time	altimeter	air_temp	relative_humidity	wind_speed	wind_direction	wind_gust_s	precip_accum_since_local_midnight	precip_accum_24_hour	dew_point_temperature_set_1d	
		INHG	Fahrenheit	%	Miles/hour	Degrees	Miles/hour	Inches	Inches	Fahrenheit	
E9939	09/07/2017 09:21 PDT	29.95	57.99	98	7	239	15.99	0.04	0.05	57.42	
E9939	09/07/2017 09:36 PDT	29.96	57.99	98	4	227	15.99	0.04	0.05	57.42	
E9939	09/07/2017 09:51 PDT	29.96	57.99	98	5.99	210	17	0.04	0.05	57.42	
E9939	09/07/2017 10:21 PDT	29.97	57.99	98	4.99	212	14	0.04	0.05	57.42	
E9939	09/07/2017 10:36 PDT	29.97	57.99	98	3	191	11.01	0.04	0.05	57.42	
E9939	09/07/2017 10:51 PDT	29.97	57.99	98	3	214	10	0.04	0.05	57.42	
E9939	09/07/2017 11:06 PDT	29.97	57.99	98	5.99	210	14	0.04	0.05	57.42	
E9939	09/07/2017 11:21 PDT	29.97	57.99	98	5.99	209	15.99	0.04	0.05	57.42	
E9939	09/07/2017 11:36 PDT	29.97	57.99	98	2.01	200	11.01	0.04	0.05	57.42	
E9939	09/07/2017 11:51 PDT	29.97	57.99	98	5.99	193	12.01	0.04	0.05	57.42	
E9939	09/07/2017 12:06 PDT	29.97	57.99	98	4.99	216	14	0.04	0.05	57.42	
E9939	09/07/2017 12:21 PDT	29.97	59	98	2.01	224	8.01	0.04	0.05	58.43	
E9939	09/07/2017 12:36 PDT	29.97	59	98	3	205	10	0.04	0.05	58.43	
E9939	09/07/2017 12:51 PDT	29.97	59	98	3	222	11.01	0.04	0.05	58.43	
E9939	09/07/2017 13:07 PDT	29.97	59	98	4	219	11.01	0.05	0.06	58.43	
E9939	09/07/2017 13:36 PDT	29.97	59	98	2.01	148	14.99	0.05	0.06	58.43	
E9939	09/07/2017 13:51 PDT	29.97	59	98	3	176	8.99	0.05	0.06	58.43	
E9939	09/07/2017 14:06 PDT	29.97	59	98	2.01	212	10	0.05	0.06	58.43	
E9939	09/07/2017 14:21 PDT	29.96	59	98	2.01	191	8.99	0.05	0.06	58.43	
E9939	09/07/2017 14:36 PDT	29.96	59	98	1.01	204	8.99	0.05	0.06	58.43	
E9939	09/07/2017 14:51 PDT	29.96	59	98	2.01	206	8.99	0.05	0.06	58.43	
E9939	09/07/2017 15:06 PDT	29.96	57.99	98	4	191	10	0.05	0.06	57.42	
E9939	09/07/2017 15:22 PDT	29.95	57.99	98	3	297	10	0.05	0.06	57.42	
E9939	09/07/2017 15:36 PDT	29.95	57.99	98	4.99	224	11.01	0.05	0.06	57.42	
E9939	09/07/2017 15:52 PDT	29.95	57.99	98	2.01	214	8.01	0.05	0.06	57.42	
E9939	09/07/2017 16:06 PDT	29.94	57.99	98	4	208	7	0.05	0.06	57.42	

Figure 11 – List of observations from E9939 surrounding the accident time

E9939 weather at 1351 PDT was reported as wind from 176° at 3 mph with gusts to 8.99 mph, temperature of 59° F, dew point temperature of 58.43° F, and a relative humidity of 98 percent.

E9939 weather at 1406 PDT was reported as wind from 212° at 2.01 mph with gusts to 10 mph, temperature of 59° F, dew point temperature of 58.43° F, and a relative humidity of 98 percent.

E9939 weather at 1421 PDT was reported as wind from 191° at 2.01 mph with gusts to 8.99 mph, temperature of 59° F, dew point temperature of 58.43° F, and a relative humidity of 98 percent.

The observations from KDVO, KSTS, and KHAF surrounding the accident time indicated MVFR¹⁰ to VFR¹¹ conditions with light rain observed the hour before the accident at KSTS. The surface wind at KDVO, KSTS, and KHAF remained from the southwest to south and onshore for 3 hours surrounding the accident timeframe. WDAC1, BBEC1, and E9939 all indicated a relative humidity of 88 percent or higher in the two hours surrounding the accident time.

¹⁰ Marginal Visual Flight Rules (MVFR) – Refers to the general weather conditions pilots can expect at the surface. MVFR criteria means a ceiling between 1,000 and 3,000 feet agl (inclusive) and/or 3 to 5 miles visibility.

¹¹ Visual Flight Rules (VFR) – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 feet agl and greater than 5 miles visibility.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)¹² model sounding was created for the accident site for 1400 PDT. The 1400 PDT HRRR sounding was plotted on a standard Skew-T log P diagram¹³ with the derived stability parameters included in figure 12 (with data from the surface to 700-hPa, or 10,000 ft msl.) This data was analyzed using the RAOB¹⁴ software package. The sounding depicted the lifted condensation level (LCL)¹⁵ at 831 ft msl, a convective condensation level (CCL)¹⁶ of 1,979 ft, and a level of free convection (LFC)¹⁷ at 831 ft. The freezing level was 13,666 ft. The precipitable water value was 1.17 inches.

¹² The HRRR is a NOAA real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three kilometer grids with three kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one hour period.

¹³ Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

¹⁴ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹⁵ LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁶ CCL – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

¹⁷ LFC – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

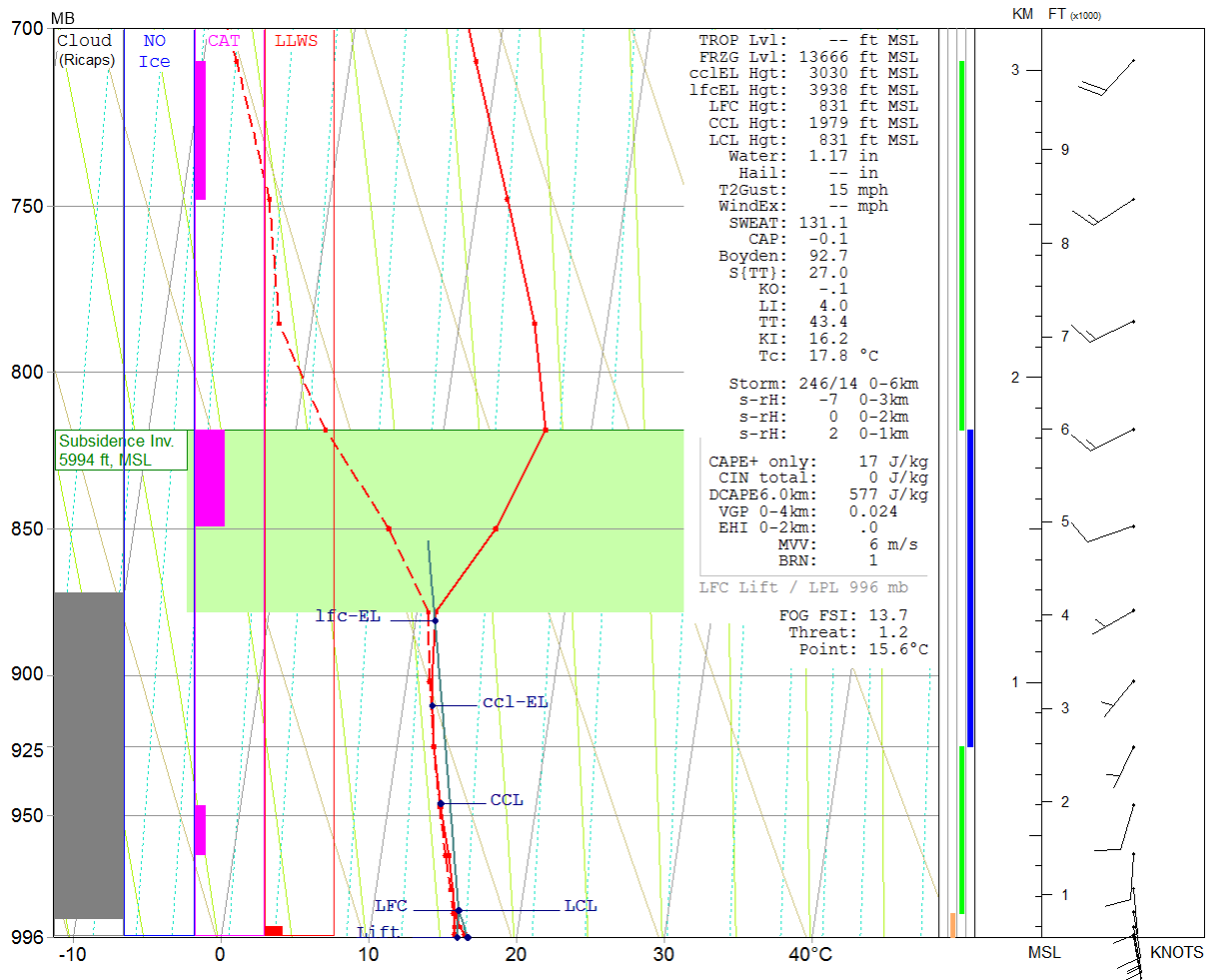


Figure 12 – 1400 PDT HRRR sounding for the accident site

The 1400 PDT HRRR sounding indicated a mostly conditionally unstable environment from the surface through 10,000 ft with a stable layer between 2,750 and 6,000 ft. RAOB identified that clouds were likely between 831 ft and 4,500 ft.

The 1400 PDT HRRR sounding's wind profile indicated a surface wind from 170° at 7 knots with the wind becoming southwesterly by 3,000 ft. The wind remained southwesterly from 3,000 ft through 10,000 ft and the wind speed was between 15 and 20 knots. RAOB indicated the possibility of light low-level wind shear (LLWS) between the surface and 700 ft. RAOB indicated the possibility of clear-air turbulence in several layers between the 2,000 and 10,000 ft.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 15 (GOES-15) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-15 bands 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm , respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1100 PDT through 1700 PDT at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 13 and 14 present the GOES-15 visible imagery from 1400 and 1430 PDT at 2X magnification with the accident site highlighted with a red square. Inspection of the visible imagery indicated cloud cover over the accident site with that cloud cover moving from southwest to northeast. Figure 15 presents the GOES-15 infrared imagery from 1400 PDT at 6X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated cloud cover over the accident site. The lower brightness temperatures (yellow colors; higher cloud tops) were located southwest and east of the accident site at the accident time. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1400 PDT HRRR sounding, the approximate cloud-top heights over the accident site were 10,000 ft at 1400 PDT. It should be noted these figures have not been corrected for any parallax error.

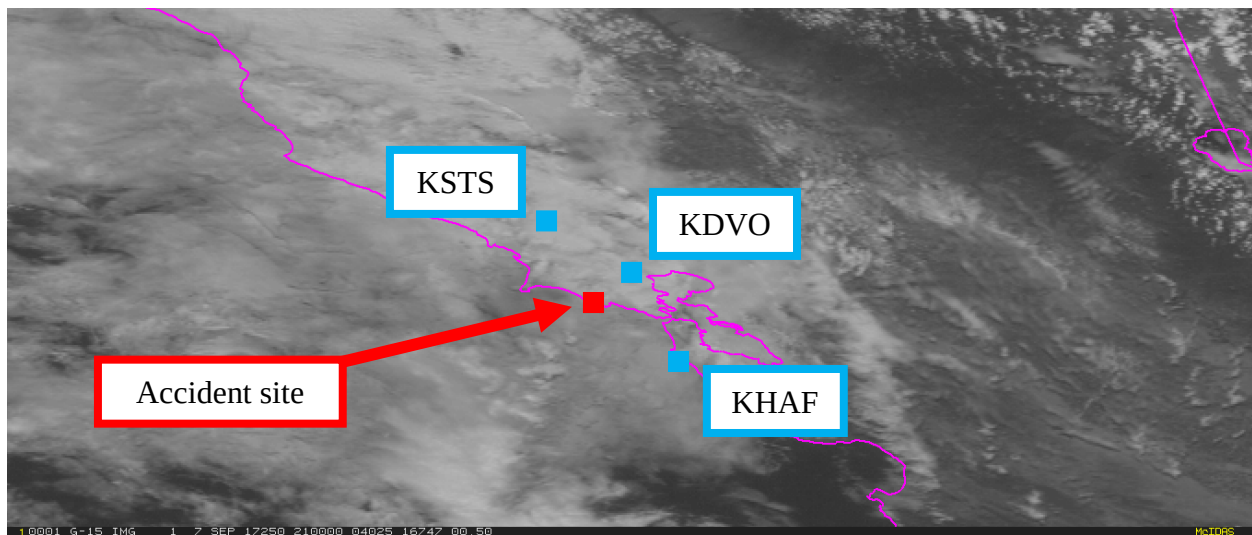


Figure 13 – GOES-15 visible image at 1400 PDT

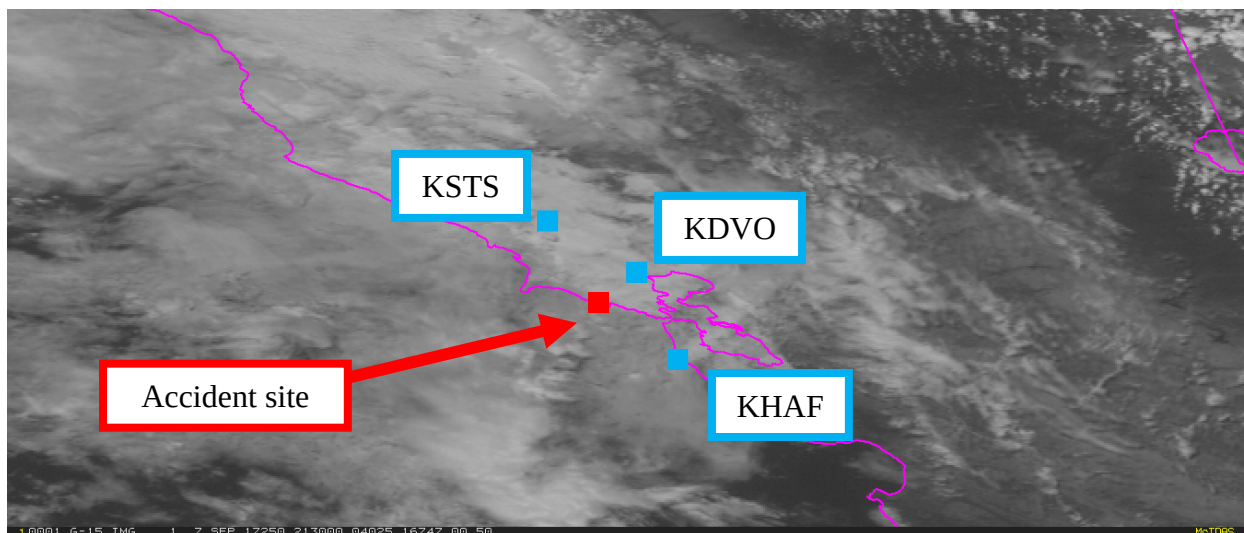


Figure 14 – GOES-15 visible image at 1430 PDT

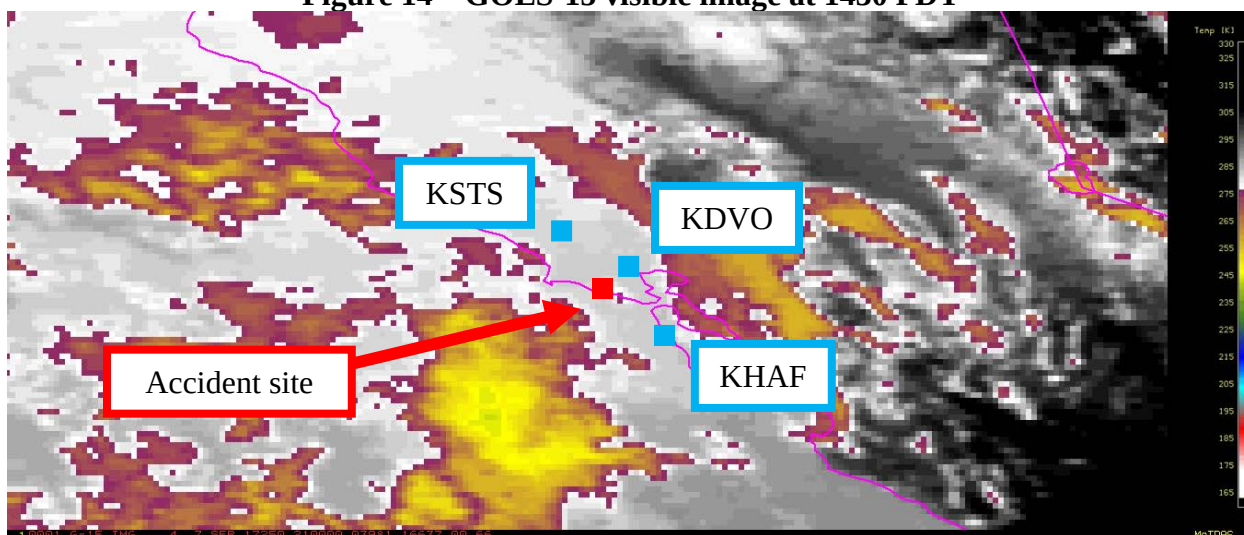


Figure 15 – GOES-15 infrared image at 1400 PDT

6.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁸ to the accident site was the Sacramento, California, radar (KDAX), which was located 60 miles northeast of the accident site at an elevation of 30 ft. Level II archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software. The KDAX data showed no precipitation targets above the accident site at the accident time.

¹⁸ The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

7.0 Pilot Reports¹⁹

All PIREPs close to the accident site from about two hours prior to the accident time to about two hours after the accident time were reviewed. Only PIREPs for below FL180²⁰ are provided below:

KPAO UA /OV PAO/TM 1920/FLUNKN/TP BE-36/SK OVC030-TOP039/RM 7SE OF PAO, DURD RWY31=

SQL UA /OV 5 NM ESE SQL ARPT/TM 1949/FL034/TP C182/SK OVC031/WX 10SM/RM TOPS 042, BASES 032 5 MILE FINAL RWY 30 SQL=

APC UA /OV APC/TM 1955/FL015/TP PRM1/SK OVC015-TOP042=

KPAO UA /OV PAO/TM 2017/FLUNKN/TP C172/SK OVC032-TOP037/TB LGT-MOD TURB ON FINAL/RM DURD=

APC UA /OV KAPC/TM 2149/FL022/TP C550/SK BKN022-TOPUNKN=

APC UA /OV KAPC/TM 2159/FL023/TP C227/SK BKN023-TOP044=

HWD UA /OV HWD/TM 2200/FL031/TP BE58/SK BKN=

Routine pilot report (UA); Over Palo Alto, California; Time – 1220 PDT (1920Z); Altitude – Unknown; Type aircraft – Beechcraft Bonanza; Sky – Overcast ceiling at 3,000 ft with tops at 3,900 ft; Remarks – 7 miles southeast of Palo Alto during descent into runway 31.

Routine pilot report (UA); 5 miles east-southeast of San Carlos, California; Time – 1249 PDT (1949Z); Altitude – 3,400 ft; Type aircraft – Cessna 182; Sky – Overcast ceiling at 3,100 ft; Weather – 10 miles visibility; Remarks – Tops at 4,200 ft, bases at 3,200 ft, on 5 mile final into runway 30.

Routine pilot report (UA); Over Napa, California; Time – 1255 PDT (1955Z); Altitude – 1,500 ft; Type aircraft – Raytheon Premier 1; Sky – Overcast ceiling at 1,500 ft with tops at 4,200 ft.

Routine pilot report (UA); Over Palo Alto, California; Time – 1317 PDT (2017Z); Altitude – Unknown; Type aircraft – Cessna 172; Sky – Overcast ceiling at 3,200 ft with tops at 3,700 ft; Turbulence – Light to moderate on final; Remarks – During descent.

Routine pilot report (UA); Over Napa, California; Time – 1449 PDT (2149Z); Altitude – 2,200 ft; Type aircraft – Cessna Citation II; Sky – Broken ceiling at 2,200 ft with tops unknown.

Routine pilot report (UA); Over Napa, California; Time – 1459 PDT (2159Z); Altitude – 2,300 ft; Type aircraft – Unknown; Sky – Broken ceiling at 2,300 ft with tops at 4,400 ft.

¹⁹ Only pilot reports with the WMO header UBCA** identifier were considered.

²⁰ Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

Routine pilot report (UA); Over Hayward, California; Time – 1500 PDT (2200Z); Altitude – 3,100 ft; Type aircraft – Beechcraft Baron; Sky – Broken.

8.0 SIGMET and CWSU Advisories

There were no Significant Meteorological Information (SIGMET) advisories valid for the accident site at the accident time.

There were no Center Weather Service Unit (CWSU) Center Weather Advisories or Meteorological Impact Statements valid for the accident site at the accident time.

9.0 AIRMETs

There was an Airmen's Meteorological Information (AIRMET) Sierra that was valid for the accident site at the accident time (figures 16 and 17). The AIRMET Sierra warned of mountain obscuration conditions in clouds, precipitation, and mist:

WAUS46 KPCI 072045

WA6S

-SFOS WA 072045

AIRMET SIERRA UPDT 3 FOR IFR AND MTN OBSCN VALID UNTIL 080300

.

AIRMET IFR...WA OR ID MT

FROM 50SW YQL TO 20WSW GTF TO 30WNW DBS TO 20WSW BOI TO 70NW REO
TO 30SSE DSD TO 40ESE OED TO OED TO 20SSW SEA TO 30E HUH TO 50SW
YQL

CIG BLW 010/VIS BLW 3SM HZ/FU. CONDS CONTG BYD 03Z THRU 09Z.

.

AIRMET IFR...WA OR CA AND CSTL WTRS

FROM 30NNE TOU TO 40ESE HQM TO ONP TO 40NNW OED TO 20E FOT TO
140WSW FOT TO 140W TOU TO 30NNE TOU

CIG BLW 010/VIS BLW 3SM PCPN/BR/HZ/FU. CONDS CONTG BYD 03Z THRU
09Z.

.

AIRMET IFR...CA AND CSTL WTRS

FROM FOT TO 20SW ENI TO 40SE SNS TO 130WSW SNS TO 140WSW FOT TO
FOT

CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG BYD 03Z THRU 09Z.

.

AIRMET MTN OBSCN...WA OR ID MT WY

FROM 20WNW HUH TO 50SW YQL TO 20SSE GTF TO 70ESE DLN TO PIH TO
60ESE REO TO 50WSW LKV TO 60SSW YKM TO 40S HQM TO TOU TO 20WNW
HUH

MTNS OBSC BY CLDS/BR/FU/HZ. CONDS CONTG BYD 03Z THRU 09Z.

.

AIRMET MTN OBSCN...WA OR CA

FROM 40S HQM TO 60SSW YKM TO 50WSW LKV TO 50NNE RBL TO 30SSW FOT
TO 90SW EUG TO 40S HQM

MTNS OBSC BY CLDS/PCPN/BR/FU/HZ. CONDS CONTG BYD 03Z THRU 09Z.

.

AIRMET MTN OBSCN...CA

FROM 40NW RBL TO 40SSW RBL TO 20W SAC TO 20WNW PYE TO 40WNW ENI

**TO 30SSW FOT TO 40NW RBL
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.**

.
**AIRMET MTN OBSCN...CA
FROM 20W SAC TO 30NNW RZS TO 60W RZS TO 30WSW SNS TO 20NW PYE TO
20W SAC
MTNS OBSC BY CLDS/BR. CONDS DVLPG 21-00Z. CONDS CONTG BYD 03Z
THRU 09Z.**

.
OTLK VALID 0300-0900Z...IFR CA AND CSTL WTRS
BOUNDED BY FOT-40WNW ENI-40SE ENI-30W RZS-30N MZB-20S MZB-60SW
MZB-70SSW RZS-140SSW SNS-130WSW SNS-150WSW FOT-FOT
CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG THRU 09Z.

....

WAUS46 KKCI 071445
WA6S
-SFOS WA 071445
AIRMET SIERRA UPDT 2 FOR IFR AND MTN OBSCN VALID UNTIL 072100

.
AIRMET IFR...WA OR CA AND CSTL WTRS
FROM HUH TO 40NNW BTG TO 50WSW BTG TO 20NE FOT TO 140WSW FOT TO
140W TOU TO HUH
CIG BLW 010/VIS BLW 3SM PCPN/BR/HZ/FU. CONDS CONTG BYD 21Z THRU
03Z.

.
AIRMET IFR...WA OR CA ID MT
FROM 40WSW YQL TO 30NNW GTF TO DLN TO 60N TWF TO 60SSE DSD TO
50SSE OED TO 50SW OED TO 60SSW EUG TO 20S BTG TO 40SSW SEA TO
30E HUH TO 40WSW YQL
CIG BLW 010/VIS BLW 3SM HZ/FU. CONDS CONTG BYD 21Z THRU 03Z.

.
AIRMET IFR...CA AND CSTL WTRS
FROM FOT TO PYE TO 50SSE SNS TO 70W EHF TO 20NW RZS TO 40ESE LAX
TO 30ESE MZB TO 220SW MZB TO 140WSW FOT TO FOT
CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG BYD 21Z THRU 03Z.

.
AIRMET MTN OBSCN...OR CA
FROM 50W BTG TO 60SE BTG TO 70NNE RBL TO 30S FOT TO 90SW EUG TO
50W BTG
MTNS OBSC BY CLDS/PCPN/BR/FU/HZ. CONDS CONTG BYD 21Z THRU 03Z.

.
**AIRMET MTN OBSCN...CA
FROM 30ESE FOT TO 50SW CZQ TO 80SSE SNS TO 40WSW SNS TO PYE TO
40W ENI TO 30SSW FOT TO 30ESE FOT
MTNS OBSC BY CLDS/BR. CONDS CONTG BYD 21Z THRU 03Z.**

.
AIRMET MTN OBSCN...WA OR ID MT WY
FROM 30SSW YQL TO 60W BIL TO 50SW BOY TO 30S BPI TO 50WSW LKV TO
60SE BTG TO 50W BTG TO TOU TO 20W HUH TO 30SSW YQL
MTNS OBSC BY CLDS/BR/FU/HZ. CONDS CONTG BYD 21Z THRU 03Z.

....

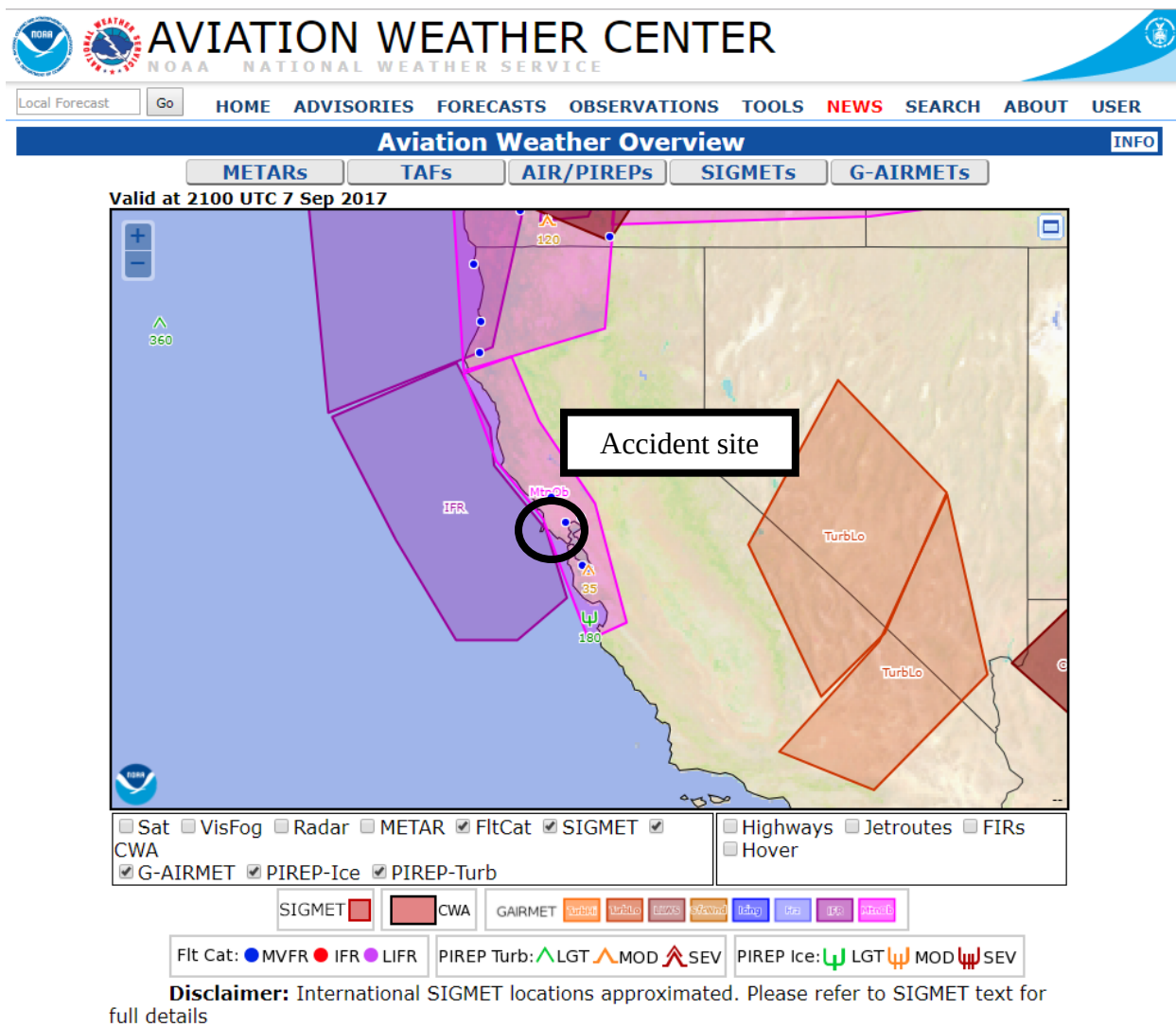


Figure 17 – AWC graphic with SIGMETs, CWAs, and AIRMETs valid at 1400 PDT

10.0 Area Forecast

The Area Forecast issued at 1245 PDT, valid at the accident time, forecasted broken clouds at 1,500 ft msl with clouds tops at 3,000 ft. At 1400 PDT the forecast expected scattered clouds at 1,500 ft with additional scattered clouds at 14,000 ft. The Area Forecast issued at 0645 PDT valid before the accident flight departed forecasted overcast clouds at 1,000 ft with tops at 3,000 ft and visibilities between 3 and 5 miles in mist. By 1300 PDT the 0645 PDT Area Forecast expected overcast clouds at 1,500 ft with occasional visibility of 5 miles in mist:

FAUS46 KKCI 071945
 FA6W
 -SFOC FA 071945
 SYNOPSIS AND VFR CLDS/WX
 SYNOPSIS VALID UNTIL 081400
 CLDS/WX VALID UNTIL 080800...OTLK VALID 080800-081400
 WA OR CA AND CSTL WTRS

.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.
NON MSL HGTS DENOTED BY AGL OR CIG.

.
SYNOPSIS...SEE SLC FA FOR SYNOPSIS.

.
WA CASCDS WWD
CSTL SXNS...BKN010 OVC030 LYRD FL270. VIS 3SM BR FU. FU TOP 120.
OTLK...IFR CIG BR.
PUGET SOUND-INTR VLY...SCT140 BKN CI. FU ALF. FU TOP FL200. 03Z
SCT030 BKN120 TOP FL270. OTLK...MVFR CIG.
CASCDS...BKN070 TOP FL240. VIS 3SM FU. FU TOP FL200. 03Z VIS 3SM
BR FU WDLY SCT SHRA. OTLK...IFR CIG FU SHRA.

.
WA E OF CASCDS
COLUMBIA BASIN...BKN030 TOP FL240. VIS 3SM FU. FU TOP FL200. 04Z
VIS 3SM FU. WDLY SCT SHRA. OTLK...IFR CIG SHRA FU.
RMNDR...BKN040-050 TOP FL240. VIS 3SM FU. FU TOP FL200.
OTLK...IFR CIG FU.

.
OR CASCDS WWD
CSTL SXNS...
N HLF...BKN020 OVC100 LYRD FL270. 02Z OVC010. VIS 3SM BR. SCT
SHRA. OTLK...IFR CIG DZ BR.
S HLF...OVC010 TOP FL270. VIS 3SM BR FU. FU TOP 170. SCT TSRA
POSS SEV. CB TOP FL370. 03Z OVC010 TOP 170. VIS 3SM BR. ISOL
SHRA. OTLK...IFR CIG DZ BR.
WILLAMETTE VLY...BKN030 BKN120 LYRD FL270. VIS 4SM FU. FU TOP
170. WDLY SCT SHRA/ISOL TSRA. CB TOP FL350. 03Z BKN030. VIS 4SM
FU. ISOL SHRA. OTLK...MVFR CIG FU.
SWRN INTR...BKN030 LYRD FL270. VIS 3SM FU. SCT SHRA/WDLY SCT TSRA
POSS SEV. CB TOP FL360. 03Z BKN035 TOP 170. VIS 3SM BR FU. WDLY
SCT SHRA. OTLK...IFR CIG BR FU.
CASCDS...BKN070 BKN140 TOP FL270. VIS 3SM FU. WDLY SCT SHRA/ISOL
TSRA. CB TOP FL350. OTLK...IFR CIG FU.

.
OR E OF CASCDS
COLUMBIA BASIN...BKN030 TOP FL240. VIS 3SM FU. FU TOP FL200. AFT
06Z ISOL SHRA. OTLK...IFR CIG FU SHRA.
RMNDR N HLF...BKN060 LYRD FL240. VIS 3SM FU. FU TOP FL200. AFT
02Z WDLY SCT SHRA. OTLK...IFR CIG FU.
S HLF...BKN140 LYRD FL270. WDLY SCT SHRA/TSRA CB TOP FL340. 05Z
BKN140. ISOL SHRA. OTLK...VFR.

.
NRN CA...STS-SAC-TVL LN NWD
CSTL SXNS...
FOT NWD...BKN010 OVC080 TOP FL270. VIS 3SM BR FU. SCT SHRA/WDLY
SCT TSRA POSS SEV. CB TOP FL370. 02Z OVC010 TOP 120. VIS 3SM BR.
OTLK...IFR CIG BR.
S OF FOT...BKN015 TOP 120. OTLK...IFR CIG BR.
SAC VLY...BKN030 BKN070 LYRD FL270. 22Z SCT040 SCT CI. 06Z SCT
CI. OTLK...VFR.
SHASTA-SISKIYOU...BKN080 OVC100 TOP FL270. VIS 3-5SM FU. FU TOP
150. SCT SHRA/WDLY SCT TSRA POSS SEV. CB TOP FL350. 03Z BKN100.
VIS 3-5SM FU HZ. FU TOP 120. ISOL SHRA. OTLK...MVFR CIG FU HZ.

NERN CA-NRN SIERNEV...SCT100 BKN140 LYRD FL270. WDLY SCT
SHRA/ISOL TSRA. CB TOP FL350. 03Z SCT140 BKN CI. ISOL SHRA.
OTLK...VFR.

.
CNTRL CA
CSTL SXNS...

SNS NWD...BKN015 TOP 030. 21Z SCT015 SCT140. 03Z BKN015 TOP 030.
OTLK...MVFR CIG.

S OF SNS...SKC OCNL SCT015. BECMG 0003 BKN015 TOP 020. OCNL VIS
4SM BR. OTLK...IFR CIG BR.

SAN JOAQUIN VLY...

MOD NWD...SCT030 SCT CI. OTLK...VFR.

S OF MOD...SKC. OTLK...VFR.

SRN SIERNEV...

NRN PTNS...SCT140. TIL 03Z WDLY SCT SHRA/ISOL TSRA. CB TOP FL350.
OTLK...VFR.

SRN PTNS...SCT140. TIL 04Z WND SWLY G25KT. OTLK...VFR.

.
SRN CA..VBG-NID-60NNW BIH LN SWD
CSTL SXNS...

CSTLN...

LAX NWD...SKC OCNL SCT025. 08Z OVC010 TOP 020. OTLK...IFR CIG.

S LAX...SKC OCNL SCT140. 03Z SCT010. 06Z OVC010 TOP 015.

OTLK...IFR CIG.

INLAND...SCT140. ISOL TSRA. CB TOP FL350. 03Z SKC. OTLK...VFR.

INTR MTNS-MOJAVE...SCT140. WND WLY G25KT. 04Z SKC. OTLK...VFR.

SRN DESERTS-IMPERIAL-COACHELLA VLYS...

NR CO RVR VLY...BKN140 TOP FL270. WDLY SCT TSRA POSS SEV. CB TOP
FL410. 05Z ISOL SHRA. OTLK...VFR 11Z VFR TSRA.

RMNDR...SCT140 SCT CI. ISOL TSRA. CB TOP FL400. WND WLY G25KT.

03Z SKC OCNL SCT CI. OTLK...VFR.

.
CSTL WTRS

WA/OR...BKN010 TOP FL270. VIS 3SM BR. WDLY SCT SHRA/ISOL TSRA. CB
TOP FL350. OTLK...IFR CIG SHRA BR.

NRN CA...BKN010 TOP FL200. WDLY SCT SHRA. OTLK...IFR CIG DZ BR.

CNTRL CA...BKN010 TOP 060. VIS 3SM BR. OTLK...IFR CIG BR.

SRN CA...SCT015. VIS 5SM HZ. WND NLY 20KT. 03Z OVC010 TOP 020.

VIS 3SM BR. OTLK...IFR CIG BR.

....

FAUS46 KPCI 071315 AAA

FA6W

-SFOC FA 071315 AMD

SYNOPSIS AND VFR CLDS/WX

SYNOPSIS VALID UNTIL 080500

CLDS/WX VALID UNTIL 072300...OTLK VALID 072300-080500

WA OR CA AND CSTL WTRS

.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.
NON MSL HGTS DENOTED BY AGL OR CIG.

.
SYNOPSIS...ALF...TROF SRN CA WITH LOW OVR NRN CA. RDG ACRS WA AND
OR. RDG BUILDING INTO SRN CA BY 05Z WITH TROF OVR NRN CA-WRN OR.
SFC...LOW PRE NRN CA. TROF FM LOW INTO CNTRL CA. PACIFIC CDFNT

REACHING WRN WA AND WRN OR BY 02Z. AT 05Z CDFNT N CNTRL WA INTO SW WA. LOW NERN WA. TROF FM LOW SWD INTO ERN OR.

.

WA CASCDS WWD

CSTL SXNS...OVC010 TOP 020. VIS 3-5SM BR. OTLK...IFR CIG BR FG.
PUGET SOUND-INTR VLY...OVC010 TOP 020. OCNL VIS 3-5SM BR. 18Z
SCT015 BKN CI. OTLK...VFR 04Z IFR CIG BR FG.
CASCDS...OVC070 LYRD FL240. VIS 3SM FU. FU TOP FL240. OTLK...IFR
FU.

.

WA E OF CASCDS

COLUMBIA BASIN...BKN030 TOP FL240. VIS 3SM FU. FU TOP FL200.
OTLK...IFR CIG FU.
RMNDR...SCT-BKN050 TOP FL200. VIS 3SM FU. FU TOP FL200.
OTLK...IFR CIG FU.

.

OR CASCDS WWD

CSTL SXNS

OVC010 LYRD FL270. VIS 3SM BR ISOL -SHRA. OTLK...IFR CIG BR FG
SHRA.
WILLAMETTE VLY...OVC015 LYRD FL270. OCNL VIS 3-5SM BR FU ISOL
-SHRA. 17Z SCT030 BKN050. WDLY SCT -SHRA/ISOL -TSRA. CB TOP
FL350. OTLK...VFR TSRA 02Z MVFR CIG BR SHRA 04Z IFR CIG BR FG
SHRA.
SWRN INTR...OVC025 LYRD FL270. OCNL VIS 3-5SM BR FU ISOL -SHRA.
17Z SCT040 BKN060. WDLY SCT -SHRA/ISOL -TSRA. CB TOP FL350.
OTLK...VFR TSRA 02Z MVFR CIG BR SHRA 04Z IFR CIG BR FG SHRA.
CASCDS...
NRN HLF...BKN070 TOP FL200. VIS 3SM FU. FU TOP FL200. 21Z SCT070
BKN CI. OTLK...VFR 01Z MVFR TSRA FU.
SRN HLF...SCT080 BKN CI. OCNL VIS 3-5SM FU ISOL -SHRA. FU TOP
FL200. 15Z SCT-BKN CI. OCNL VIS 5SM FU. 19Z SCT070 BKN130 TOP
FL200. WDLY SCT -SHRA/ISOL -TSRA. CB TOP FL350. OTLK...VFR TSRA
03Z MVFR CIG BR FU SHRA.

.

OR E OF CASCDS

CNTRL...

NRN HLF...BKN030 TOP FL240. VIS 3SM FU. FU TOP FL200. OTLK...IFR
CIG FU.
SRN HLF...SCT080 BKN CI. OCNL VIS 3-5SM FU ISOL -SHRA. FU TOP
FL200. 15Z SCT-BKN CI. OCNL VIS 5SM FU. 19Z SCT070 BKN130 TOP
FL200. WDLY SCT -SHRA/ISOL -TSRA. CB TOP FL350. OTLK...TSRA 03Z
MVFR CIG BR FU SHRA.
ERN...
NRN HLF...SCT-BKN060 TOP 170. VIS 3SM FU. FU TOP FL200.
OTLK...IFR CIG FU.
SRN HLF...FEW CI. OCNL VIS 3-5SM FU. FU TOP FL200. 22Z SCT-BKN
CI. ISOL -SHRA/-TSRA. CB TOP FL350. OTLK...VFR TSRA.

.

NRN CA...STS-SAC-TVL LN NWD...UPDT

CSTL SXNS...OVC010 LYRD FL270. VIS 3SM BR. WDLY SCT -SHRA/-TSRA.
CB TOP FL350. 22Z BKN015. OTLK...MVFR CIG 02Z IFR CIG BR FG.
SAC VLY...SCT030 BKN050 TOP FL270. OTLK...VFR.
SHASTA-SISKIYOU-S-NERN CA...SCT080 BKN CI. OCNL VIS 3-5SM FU ISOL
-SHRA. FU TOP FL200. 15Z SCT-BKN CI. OCNL VIS 5SM FU. 17Z SCT070
BKN130 TOP FL200. WDLY SCT -SHRA/ISOL -TSRA. CB TOP FL350.

OTLK...VFR TIL 01Z TSRA 04Z MVFR CIG BR FU SHRA.
 NRN SIERNEV...BKN080 TOP 150. 21Z WDLY SCT -SHRA/ISOL -TSRA.
 OTLK...VFR TIL 03Z TSRA.

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CNTRL CA
 CSTL SXNS...
**CSTLN...OVC010 TOP 030. VIS 3-5SM BR. 20Z OVC015. OCNL VIS 5SM
 BR. OTLK...MVFR CIG BR 01Z IFR CIG BR FG.**
 INLAND...OVC015 TOP 040. OCNL VIS 5SM BR. 19Z BKN030. OTLK...MVFR
 CIG BR 04Z IFR CIG BR FG.
 SAN JOAQUIN VLY...SCT CI. OTLK...VFR.
 SRN SIERNEV...FEW100 SCT CI. OTLK...VFR 00Z SHRA.

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SRN CA..VBG-NID-60NNW BIH LN SWD
 CSTL SXNS...
 CSTLN...OVC010 TOP 030. VIS 3-5SM BR. 20Z OVC015. OCNL VIS 5SM
 BR. OTLK...MVFR CIG BR 01Z IFR CIG BR FG.
 INLAND...BKN010 TOP 020. OCNL VIS 5SM BR. 18Z SCT030. OTLK...VFR
 04Z IFR CIG BR FG.
 INTR MTNS-MOJAVE-SRN DESERTS...SCT CI. OTLK...VFR.
 IMPERIAL-COACHELLA VLYS...BKN CI. ISOL -SHRA. 18Z SCT CI.
 OTLK...VFR.

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CSTL WTRS
 WA...OVC010 LYRD FL270. VIS 3-5SM BR ISOL -SHRA. OTLK...IFR CIG
 BR FG SHRA.
 OR...OVC010 LYRD FL270. VIS 3-5SM BR ISOL -SHRA. OTLK...IFR CIG
 BR FG SHRA.
 CA...OVC010 TOP 030. VIS 3-5SM BR. OTLK...IFR CIG BR FG.

11.0 Terminal Aerodrome Forecast

San Francisco International Airport (KSFO) was the closest site to the accident site with an NWS Terminal Aerodrome Forecast (TAF). KSFO was located 25 miles southeast of the accident site. The TAF valid at the accident time was issued at 1345 PDT and was valid for a 27-hour period beginning at 1400 PDT. The 1345 PDT TAF for KSFO was as follows:

KSFO 072045Z 0721/0824 **21009KT P6SM FEW025 BKN035 BKN150**
 FM072200 24012KT P6SM FEW025 SCT030 SCT150
 FM080300 26009KT P6SM BKN012
 FM080500 26007KT P6SM OVC008
 FM080800 27006KT P6SM OVC006
 FM081900 27008KT P6SM SCT008
 FM082200 27014KT P6SM FEW010=

The 1345 PDT TAF expected a wind from 210° at 9 knots, greater than 6 miles visibility, few clouds at 2,500 ft agl, a broken ceiling at 3,500 ft agl, and broken skies at 15,000 ft agl.

12.0 NWS Area Forecast Discussion

The NWS Office in San Francisco Bay Area, California, issued the following Area Forecast Discussion (AFD) at 1347 PDT (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed the marine layer and that the MVFR conditions were expected to improve through the afternoon:

970
FXUS66 KMTR 072047
AFDMTR

Area Forecast Discussion
National Weather Service San Francisco Bay Area
147 PM PDT Thu Sep 7 2017

.SYNOPSIS...Expected overnight clouds and coastal drizzle the next few days. Temperatures will also slowly warm with inland locations returning to very warm levels by Sunday.

&&

.DISCUSSION...as of 2:00 PM PDT Thursday...After many reports of very light rain or drizzle this morning things quieted down by noon with all activity shifting out of our CWA. This precipitation was caused by a very weak system that moved in from the southwest that also had ample moisture to utilize. Amounts in almost all cases were less than 0.05"

Thanks in large part to cloudy conditions and lower 850 mb levels, temperatures have been much cooler today compared to yesterday. In fact, locations that were around 115 just a few days ago are struggling to get out of the lower 70s. In some spots today will turn out to be 15 degrees cooler than normal.

Synoptically a cut-off low will form in a trough off the coast over the weekend. The low will meander off the California coast into the middle of next week before finally ejecting off to the east. At the same time 850 mb temperatures will increase going into the weekend with values forecast to eventually exceed 20C. On Sunday inland highs will be in the 80s and 90s while coastal locations will mostly be in the 70s. Patchy drizzle is possible every night.

Dry weather is in the cards for most days, although for Sunday into Monday there are indications that moisture and instability could move in from the south. A slight chance for showers and thunderstorms were kept in the forecast for Monterey and San Benito counties.

Temperatures are forecast to cool once again next work week. Inland highs will retreat back into the 70s and 80s. Coastal spots will be in the 60s and 70s.

&&

.AVIATION...As of 11:00 AM PDT Thursday for 18Z TAFs. Widespread MVFR cigs. A weak low pressure system has brought an elevated cloud deck across most of the forecast area this morning. A weak surface mesolow off of Point Reyes is helping to advect in additional cloudiness to the region at this time, bolstering the depth and coverage of the cloud deck late this morning. Look for slowly improving conditions as the main low pressure shifts out of the area through the day. Primarily VFR expected across the area after 20-21Z with some lingering high level clouds. For tonight, early arrival of marine stratus is anticipated across the region, beginning as early as 00-01Z. CIGS will initially be borderline IFR/MVFR then descend to LIFR overnight. Low confidence forecast overall.

Vicinity of KSFO...MVFR thru around 21Z then VFR. Low clouds return as early as 01Z. Light west winds, up to 12 kt in the afternoon.

SFO Bridge Approach...Similar to KSFO.

Monterey Bay Terminals...Upper low transitioning away from KMRY/KSNS... so could see earlier VFR there than elsewhere. Early return of stratus as early as 01Z early this evening. Light onshore winds.

&&

.MARINE...as of 10:50 AM PDT Thursday...Generally light south winds today with the strongest winds along the west facing Santa Cruz and Big Sur coastlines. Winds will begin to veer to the northwest and increase by the end of the week as high pressure restrengthens over the eastern Pacific. West to northwest swell 5 ft or less with 13 second period today.... increasing to 18 tonight when a new wave train arrives.

&&

**.MTR WATCHES/WARNINGS/ADVISORIES...
.Tngt...SCA...Pt Pinos to Pt Piedras Blancas 0-10 nm until 4 AM**

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13.0 Winds and Temperature Aloft Forecast

The NWS 1302 PDT Winds and Temperature Aloft forecast valid for the closest point to the accident site is included below:

```
FBUS31 KWN0 072002
FD1US1
- DATA BASED ON 071800Z
VALID 080000Z   FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT  3000    6000    9000   12000   18000   24000   30000   34000   39000

SFO 2809 2018+17 1917+10 2016+04 2020-11 1925-22 192836 193542 203948
```

The accident site was closest to the SFO forecast point. The 1302 PDT SFO forecast indicated a wind at 3,000 ft. from 280° at 9 knots and a wind at 6,000 ft from 200° at 18 knots with a temperature of 17° C.

14.0 Pilot Weather Briefing

A search of official weather briefing sources such as Leidos weather briefings and Direct User Access Terminal Service (DUATS) was done. The accident pilot received an official DUATS weather briefing at 1102 PDT (Attachment 2). The DUATS briefing contained the standard information including the latest METARs, TAFs, Area Forecast, AIRMETs, and Winds Aloft Forecast all valid along the proposed route of flight.

A search of archived data from ForeFlight was done and the accident pilot requested and received weather briefing information at 1101 PDT (Attachment 3) and filed a flight plan at 1101 PDT (Attachment 4). Additional weather briefings were discovered by Leidos with the accident pilot receiving weather information for the accident flight route at 1023 and 1058 PDT as well as at 2037 PDT on September 6 (Attachments 5, 6, 7, respectively). The ForeFlight weather briefing from 1101 PDT contained the standard information including the latest METARs, Area Forecast, AIRMETs, 3 PIREPs, TAFs, and Winds Aloft Forecast, which were all valid along the proposed route of flight (Attachment 3).

15.0 Additional Information

A summary of ATC communications with the accident flight was provided by the FAA. At 1317 PDT, the accident pilot advised ATC that he was going to descend below the marine layer. The accident pilot asked ATC if they knew what the bases of the clouds were. ATC responded that they did not know what the bases of the clouds were. The accident pilot said he would descend to 1,500 ft. For more information please see attachment 1.

16.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on September 7, 2017, indicated the following:

SUN

Begin civil twilight	0620 PDT
Sunrise	0646 PDT
Sun transit	1309 PDT
Sunset	1931 PDT
End civil twilight	1957 PDT

E. LIST OF ATTACHMENTS

Attachment 1 – Summary of ATC communications with N737QQ

Attachment 2 – DUATS weather briefing from 1102 PDT

Attachment 3 – ForeFlight weather briefing from 1101 PDT

Attachment 4 – Accident flight's flight plan from 1101 PDT

Attachment 5 – ForeFlight weather briefing from 1023 PDT

Attachment 6 – ForeFlight weather briefing from 1058 PDT

Attachment 7 – ForeFlight weather briefing from 2037 PDT on September 6

Submitted by:

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