



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
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Weather Study

METEOROLOGY

WPR17FA021

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A. ACCIDENT

Location: 2 miles north-northeast Pukoo, Hawaii
Date: November 15, 2016
Time: 1841 Hawaii standard time
0441 Coordinated Universal Time (UTC) on November 16, 2016
Aircraft: Hughes 500D, N81GG

B. METEOROLOGIST

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Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On November 15, 2016, about 1841 Hawaii standard time, a turbine-powered Hughes 369D (500D) helicopter, N81GG, was destroyed after impacting mountainous tree-covered terrain about 1-mile north of Pukoo, Hawaii. The certificated airline transport pilot and the sole passenger were fatally injured. The helicopter was registered to the pilot and operated as a visual flight rules (VFR) personal flight conducted under Title 14 *Code of Federal Regulations* Part 91. No flight plan was filed. At the time of the accident, dark night, visual meteorological conditions prevailed with localized reports of low visibility with heavy rain showers. The flight departed the Honolulu International Airport, Hawaii, at 1756, destined for a private residence near Pukoo, located on the Island of Molokai.

D. 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 Hawaii standard time (HST) on November 15, 2016, and are based upon the 24-hour clock, where local time is -10 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 accident site was located at latitude 21.0997° N, longitude 156.7922° W, at an approximate elevation of 1,290 feet.

E. WEATHER 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 NOAA Pacific Surface Analysis Chart for 1400 and 2000 HST are provided as figures 1 and 2 with the approximate location of the accident site marked within the red circle. The charts depicted a dissipating frontal boundary well northeast of the Hawaiian Islands. A surface high pressure center was located in the eastern Pacific Ocean well northeast of the Hawaiian Islands and it moved eastward between 1400 and 2000 HST as well, and the surface high pressure center had a surface pressure of 1033-hectopascals (hPa). A hurricane force low in the northern Pacific Ocean weakened and became a storm force low in the northern Pacific Ocean between 1400 and 2000 HST with the surface low pressure center and its associated frontal boundary well north and west of the Hawaiian Islands. Near the Hawaiian Islands the easterly trade wind between 15 and 25 knots dominated local weather pattern conditions.

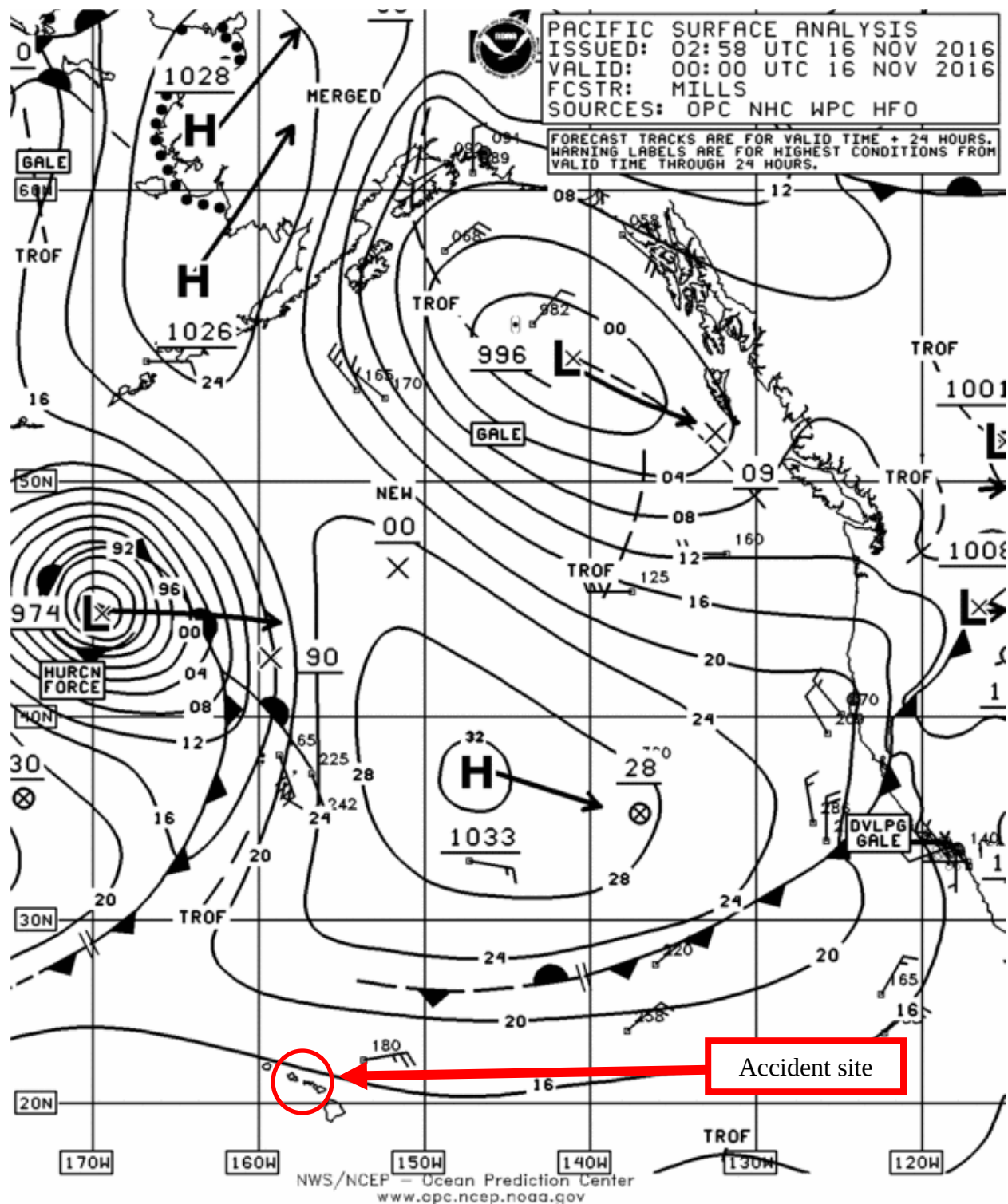


Figure 1 – NOAA Pacific Surface Analysis Chart for 1400 HST

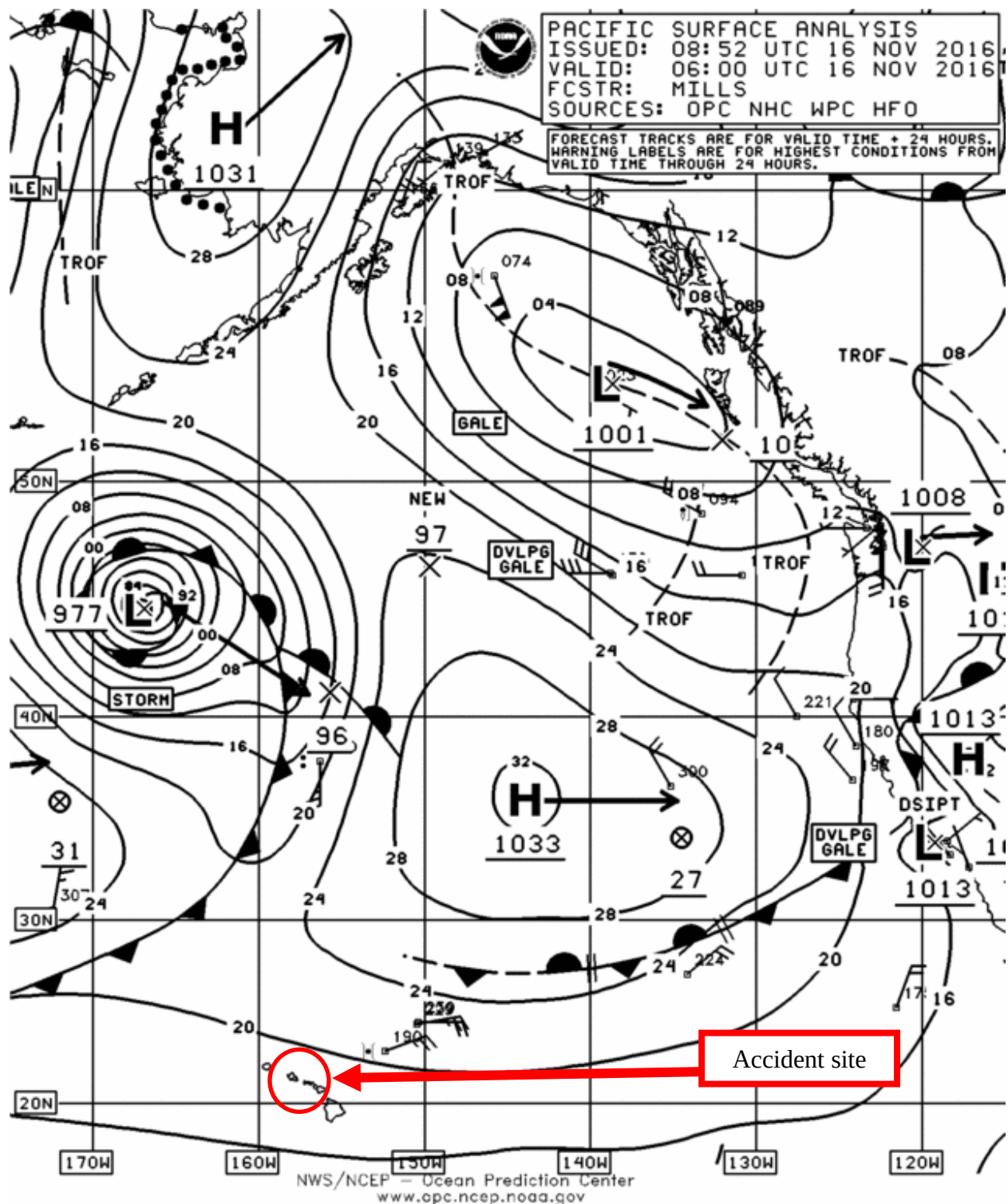


Figure 2 – NOAA Pacific Surface Analysis Chart for 2000 HST

1.2 Upper Air Charts

The NOAA 500-hPa Analysis Chart for 1400 HST is presented in figure 3. The 500-hPa chart depicted a mid-level high pressure center just to the northeast of the Hawaiian Islands with easterly trade winds at 500-hPa at 35 knots above the Hawaiian Islands.

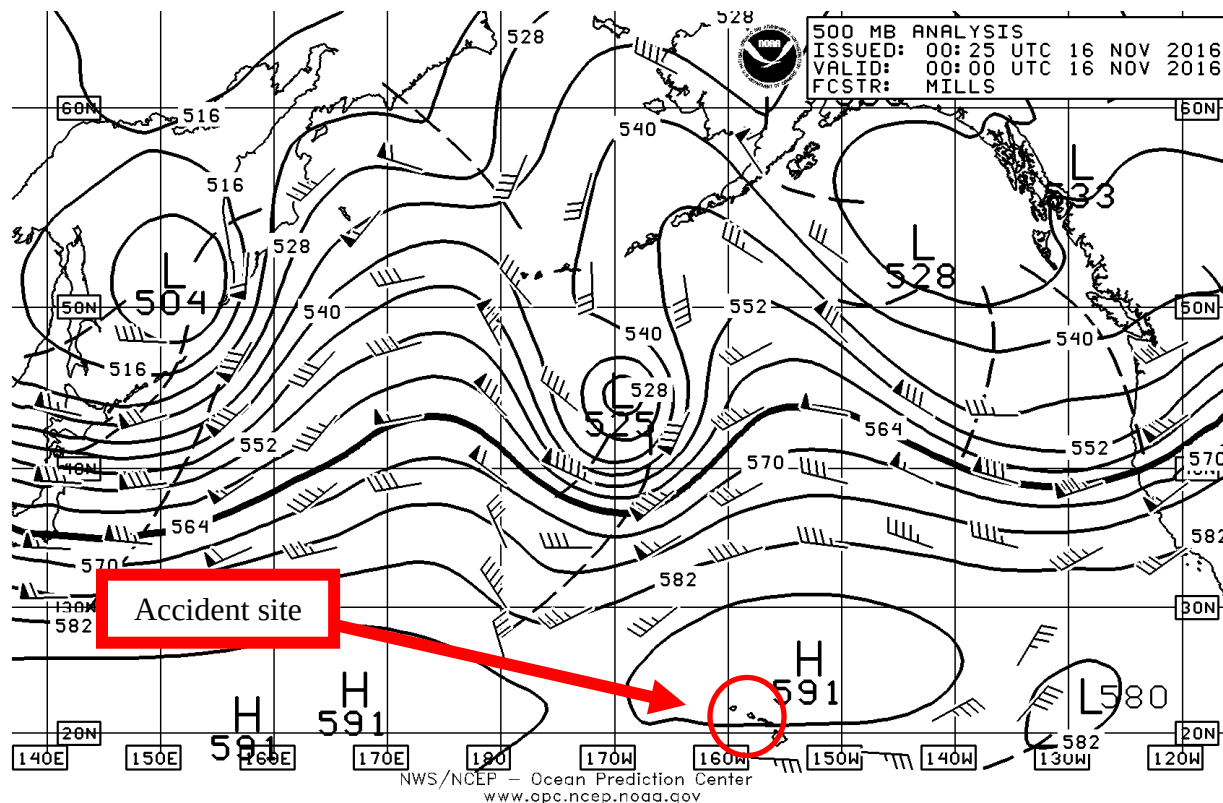


Figure 3 – NOAA 500-hPa Analysis Chart for 1400 HST

2.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 4 is a local terrain map of the region with the accident site and the closest weather reporting locations marked.

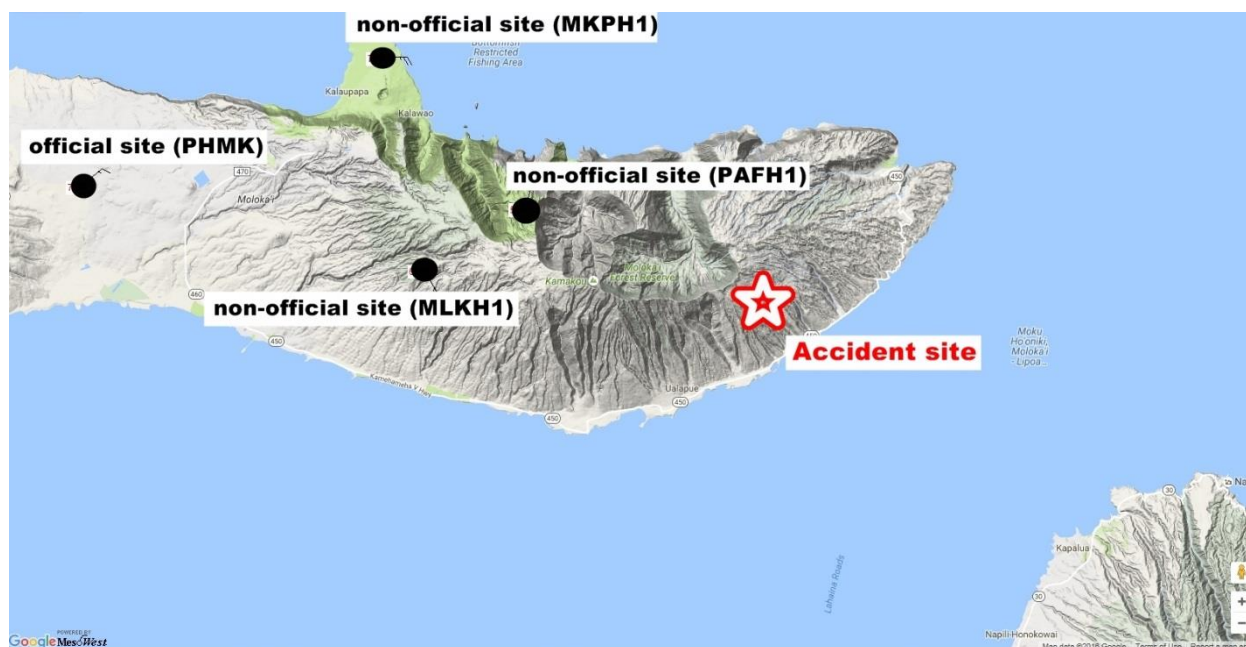


Figure 4 – Terrain map of the accident area with the location of the accident site and surface observation sites

Molokai Airport (PHMK) had the closest official weather station to the accident site located on Molokai Island which was located 6 miles northwest of Kaunakakai, Hawaii. PHMK had an Automated Surface Observing System (ASOS¹) whose reports were supplemented by air traffic control. PHMK was located 17 miles west-northwest of the accident site, at an elevation of 454 feet, and had a 11° easterly magnetic variation² (figure 4). The following observations were taken and disseminated during the times surrounding the accident:³

[1054 HST] METAR PHMK 152054Z 04013KT 10SM FEW043 28/18 A3007 RMK AO2
SLP183 T02780178 50003=

[1154 HST] METAR PHMK 152154Z 05015G22KT 10SM CLR 28/18 A3005 RMK AO2
SLP176 T02830183=

[1254 HST] METAR PHMK 152254Z 05015G23KT 10SM CLR 29/19 A3002 RMK AO2
SLP165 T02940189=

¹ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

² Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1980, latest measurement taken from <http://www.airnav.com/airport/PHMK>

³ The bold sections in this NWS product and the rest of products in this report are intended to highlight the sections that directly reference the weather conditions that effected the accident location around the accident time. The local times in section 3.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[1354 HST] METAR PHMK 152354Z 03015G24KT 10SM FEW050 28/19 A2999 RMK AO2 PK WND 04028/2310 SLP157 T02830194 10294 20256 58025=

[1454 HST] METAR PHMK 160054Z 04015G28KT 10SM FEW040 27/20 A3000 RMK AO2 PK WND 04028/0040 SLP161 T02670200=

[1554 HST] METAR PHMK 160154Z 04018G28KT 10SM BKN055 26/20 A3000 RMK AO2 PK WND 04030/0110 SLP160 T02610200=

[1654 HST] METAR PHMK 160254Z 04015G22KT 10SM BKN045 BKN050 26/20 A3001 RMK AO2 PK WND 04027/0241 SLP164 T02560200 53006=

[1754 HST] METAR PHMK 160354Z 03014G23KT 10SM SCT044 24/21 A3002 RMK AO2 PK WND 04026/0337 RAB37E48 SLP166 P0000 T02390206=

ACCIDENT TIME 1841 HST

[1854 HST] METAR PHMK 160454Z AUTO 03015G21KT 10SM BKN048 BKN055 24/21 A3004 RMK AO2 SLP173 T02440206 TSNO=

[1954 HST] METAR PHMK 160554Z AUTO 06009G18KT 10SM FEW049 24/21 A3006 RMK AO2 RAB0458E30 SLP180 P0000 60000 T02390206 10283 20239 53016 TSNO=

[2054 HST] METAR PHMK 160654Z AUTO 04013G21KT 10SM SCT039 BKN050 24/21 A3007 RMK AO2 SLP183 T02440206 TSNO=

[2154 HST] METAR PHMK 160754Z AUTO 04012G17KT 10SM SCT049 24/21 A3007 RMK AO2 SLP182 T02390206 TSNO=

PHMK weather at 1654 HST, wind from 040° at 15 knots with gusts to 22 knots, 10 miles visibility, a broken ceiling 4,500 feet above ground level (agl), broken skies at 5,000 feet agl, temperature of 26° Celsius (C), dew point temperature of 20° C, and an altimeter setting of 30.01 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 040° at 27 knots at 1641 HST, sea level pressure 1016.4 hPa, temperature 25.6° C, dew point temperature 20.0° C, 3-hourly pressure increase of 0.6 hPa.

PHMK weather at 1754 HST, wind from 030° at 14 knots with gusts to 23 knots, 10 miles visibility, scattered clouds 4,400 feet agl, temperature of 24° C, dew point temperature of 21° C, and an altimeter setting of 30.02 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 040° at 26 knots at 1737 HST, rain began at 1737 HST and rain ended at 1748 HST, sea level pressure 1016.6 hPa, one-hourly precipitation of a trace, temperature 23.9° C, dew point temperature 20.6° C.

PHMK weather at 1854 HST, automated, wind from 030° at 15 knots with gusts to 21 knots, 10 miles visibility, a broken ceiling at 4,800 feet agl, broken skies at 5,500 feet agl, temperature of 24° C, dew point temperature of 21° C, and an altimeter setting of 30.04 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1017.3 hPa, temperature 24.4° C, dew point temperature 20.6° C, lightning detection sensor is not operating.

PHMK weather at 1954 HST, automated, wind from 060° at 9 knots with gusts to 18 knots, 10 miles visibility, few clouds 4,900 feet agl, temperature of 24° C, dew point temperature of 21° C, and an altimeter setting of 30.06 inches of mercury. Remarks: automated station with a precipitation discriminator, rain began at 1858 HST and rain ended at 1930 HST, sea level pressure 1018.0 hPa, one-hourly precipitation of a trace, 6-hourly precipitation of a trace, temperature 23.9° C, dew point temperature 20.6° C, 6-hourly maximum temperature of 28.3° C, 6-hourly minimum temperature of 23.9° C, 3-hourly pressure increase of 1.6 hPa, lightning detection sensor is not operating.

PUU ALII (PAFH1) was a Remote Automatic Weather Station (RAWS) and was the closest non-official surface observation site to the accident site located 7 miles west-northwest of the accident site at an elevation of 3,805 feet (figure 4) and figure 5 contains the observations surrounding the accident time:

# STATION: PAFH1											
# STATION NAME: PUU ALII											
# LATITUDE: 21.140833											
# LONGITUDE: -156.902317											
# ELEVATION (ft): 3805											
# STATE: HI											
Station_ID	Date_Time	air_temp	relative_humidity	wind_speed	wind_direction	wind_gust	precip_accum	peak_wind_speed	peak_wind_direction	dew_point_temperature	wind_cardinal_direction_set_1d
		Fahrenheit	%	Miles/hour	Degrees	Miles/hour	Inches	Miles/hour	Degrees	Fahrenheit	Code
PAFH1	11/15/2016 09:22 HST	57.99		97	3	275	13	53.57	13	131	57.13 W
PAFH1	11/15/2016 10:22 HST	60.01		89	2.01	207	14	53.57	14	235	56.73 SSW
PAFH1	11/15/2016 11:22 HST	62.01		88	2.01	319	12.01	53.57	12.01	238	58.39 NW
PAFH1	11/15/2016 12:22 HST	63		90	2.01	340	13	53.57	13	45	60 NNW
PAFH1	11/15/2016 13:22 HST	63		97	3	321	15.99	53.57	15.99	35	62.13 NW
PAFH1	11/15/2016 14:22 HST	61		100	3	282	14.99	53.57	14.99	249	61 WNW
PAFH1	11/15/2016 15:22 HST	61		100	3	88	12.01	53.58	12.01	51	61 E
PAFH1	11/15/2016 16:22 HST	61		100	3	11	13	53.6	13	89	61 N
PAFH1	11/15/2016 17:22 HST	61		100	3	208	17	53.61	17	254	61 SSW
PAFH1	11/15/2016 18:22 HST	61		100	3	285	14.99	53.63	14.99	70	61 WNW
PAFH1	11/15/2016 19:22 HST	61		100	3	346	18.01	53.66	18.01	42	61 NNW
PAFH1	11/15/2016 20:22 HST	61		100	3	33	14.99	53.75	14.99	59	61 NNE
PAFH1	11/15/2016 21:22 HST	61		100	4	19	17	53.85	17	68	61 NNE
PAFH1	11/15/2016 22:22 HST	61		100	4	29	24.99	53.92	24.99	245	61 NNE
PAFH1	11/15/2016 23:22 HST	60.01		100	4	22	21	53.97	21	49	60.01 NNE
PAFH1	11/16/2016 00:22 HST	60.01		100	4	18	15.99	54	15.99	340	60.01 NNE
PAFH1	11/16/2016 02:22 HST	60.01		100	3	320	18.99	54.08	18.99	50	60.01 NW
PAFH1	11/16/2016 03:22 HST	59		100	4	12	13	54.1	13	245	59 NNE
PAFH1	11/16/2016 04:22 HST	57.99		100	4	229	12.01	54.1	12.01	244	57.99 SW
PAFH1	11/16/2016 05:22 HST	57		100	3	233	17	54.11	17	239	57 SW
PAFH1	11/16/2016 06:22 HST	55.99		99	4	224	17	54.11	17	214	55.71 SW
PAFH1	11/16/2016 07:22 HST	55.99		98	4	224	17	54.11	17	58	55.43 SW
PAFH1	11/16/2016 08:22 HST	57		98	3	240	15.99	54.11	15.99	33	56.43 WSW

Figure 5 – List of observations from PAFH1 surrounding the accident time

PAFH1 weather at 1722 HST was reported as wind from 208° at 2.6 knots with gusts to 14.8 knots, temperature of 16.1° C, a dew point temperature of 16.1° C, and a station total precipitation accumulation of 53.61 inches.

PAFH1 weather at 1822 HST was reported as wind from 285° at 2.6 knots with gusts to 13.0 knots, temperature of 16.1° C, a dew point temperature of 16.1° C, and a station total precipitation accumulation of 53.63 inches.

PAFH1 weather at 1922 HST was reported as wind from 346° at 2.6 knots with gusts to 15.7 knots, temperature of 16.1° C, a dew point temperature of 16.1° C, and a station total precipitation accumulation of 53.66 inches.

MOLOKAI 1 (MLKH1) was a RAWS and was a non-official surface observation site located 9 miles west of the accident site at an elevation of 2,733 feet (figure 4) and figure 6 contains the observations surrounding the accident time:

# STATION: MLKH1												
# STATION NAME: MOLOKAI 1												
# LATITUDE: 21.115000												
# LONGITUDE: -156.9475												
# ELEVATION [ft]: 2733												
# STATE: HI												
Station_ID	Date_Time	air_temp	se	relative_humidity	wind_speed	wind_direction	wind_gust_s	precip_accum	peak_wind_speed	peak_wind_direction	dew_point_temperature	wind_cardinal_direction_set_1d
		Fahrenheit		%	Miles/hour	Degrees	Miles/hour	Inches	Miles/hour	Degrees	Fahrenheit	Code
MLKH1	11/15/2016 09:37 HST	70		66	8.01	105	18.01	26.69	18.01	71	58.07	ESE
MLKH1	11/15/2016 10:37 HST	72		57	5.99	109	18.99	26.69	18.99	116	55.88	ESE
MLKH1	11/15/2016 11:37 HST	73		60	4	56	21	26.69	21	72	58.25	NE
MLKH1	11/15/2016 12:37 HST	73.99		61	4	38	18.99	26.69	18.99	14	59.65	NE
MLKH1	11/15/2016 13:37 HST	73.99		67	4.99	99	15.99	26.69	15.99	2	62.3	E
MLKH1	11/15/2016 14:37 HST	75		65	3	180	18.01	26.69	18.01	18	62.4	S
MLKH1	11/15/2016 15:37 HST	73		71	4.99	115	15.99	26.69	15.99	139	63	ESE
MLKH1	11/15/2016 16:37 HST	70		78	3	140	15.99	26.69	15.99	106	62.79	SE
MLKH1	11/15/2016 17:37 HST	69.01		82	3	249	11.01	26.69	11.01	208	63.25	WSW
MLKH1	11/15/2016 18:37 HST	68		85	1.01	200	14.99	26.69	14.99	111	63.29	SSW
MLKH1	11/15/2016 20:37 HST	66		92	1.01	276	5.99	26.7	5.99	297	63.59	W
MLKH1	11/15/2016 21:37 HST	66		96	2.01	236	13	26.74	13	113	64.82	SW
MLKH1	11/15/2016 22:37 HST	64.99		97	2.01	2	8.01	26.76	8.01	274	64.11	N
MLKH1	11/15/2016 23:37 HST	64.99		95	2.01	210	11.01	26.78	11.01	10	63.51	SSW
MLKH1	11/16/2016 00:37 HST	64.99		95	2.01	280	8.99	26.8	8.99	294	63.51	W
MLKH1	11/16/2016 02:37 HST	64		93	3	282	7	26.84	7	265	61.92	WNW
MLKH1	11/16/2016 03:37 HST	64		88	2.01	21	10	26.85	10	289	60.35	NNE
MLKH1	11/16/2016 04:37 HST	63		83	4	78	17	26.85	17	73	57.72	ENE
MLKH1	11/16/2016 05:37 HST	62.01		80	3	332	10	26.85	10	114	55.72	NNW
MLKH1	11/16/2016 06:37 HST	64		73	3	40	11.01	26.85	11.01	37	55.11	NE
MLKH1	11/16/2016 07:37 HST	64		70	4	300	13	26.85	13	184	53.95	WNW
MLKH1	11/16/2016 08:37 HST	66.99		69	4.99	296	15.99	26.85	15.99	276	56.43	WNW

Figure 6 – List of observations from MLKH1 surrounding the accident time

MLKH1 weather at 1737 HST was reported as wind from 249° at 2.6 knots with gusts to 9.6 knots, temperature of 20.6° C, a dew point temperature of 17.4° C, and a station total precipitation accumulation of 26.69 inches.

MLKH1 weather at 1837 HST was reported as wind from 200° at 1-knot with gusts to 13.0 knots, temperature of 20° C, a dew point temperature of 17.4° C, and a station total precipitation accumulation of 26.69 inches.

MLKH1 weather at 1937 HST was reported as wind from 276° at 1-knot with gusts to 5.2 knots, temperature of 18.9° C, a dew point temperature of 17.6° C, and a station total precipitation accumulation of 26.70 inches.

MAKAPULAPAI (MKPH1) was a RAWS and was a non-official surface observation site located 12 miles west-northwest of the accident site at an elevation of 75 feet (figure 4) and figure 7 contains the observations surrounding the accident time:

# STATION: MKPH1											
# STATION NAME: MAKAPULAPAI											
# LATITUDE: 21.203333											
# LONGITUDE: -156.966111											
# ELEVATION [ft]: 75											
# STATE: HI											
Station_ID	Date_Time	air_temp_s	relative_humidity	wind_speed	wind_direction	wind_gust_s	precip_accum	peak_wind_speed	peak_wind_direction	dew_point_temperature	wind_cardinal_direction_set_1d
		Fahrenheit	%	Miles/hour	Degrees	Miles/hour	Inches	Miles/hour	Degrees	Fahrenheit	Code
MKPH1	11/15/2016 09:15 HST	80.01		68	21	94	32.99	33.72	32.99	92	68.49 E
MKPH1	11/15/2016 10:15 HST	81		62	24.99	88	34	33.72	34	94	66.75 E
MKPH1	11/15/2016 11:15 HST	82.99		61	22.01	88	31	33.72	31	86	68.16 E
MKPH1	11/15/2016 12:15 HST	82.99		62	22.01	84	31	33.72	31	89	68.63 E
MKPH1	11/15/2016 13:15 HST	81		69	22.01	86	32.01	33.72	32.01	85	69.86 E
MKPH1	11/15/2016 14:15 HST	79		74	22.01	82	34	33.72	34	90	69.99 E
MKPH1	11/15/2016 15:15 HST	78.01		75	24	92	35.99	33.72	35.99	104	69.43 E
MKPH1	11/15/2016 16:15 HST	78.01		76	22.01	90	34.99	33.72	34.99	92	69.82 E
MKPH1	11/15/2016 17:15 HST	75.99		81	22.01	89	32.01	33.72	32.01	91	69.72 E
MKPH1	11/15/2016 18:15 HST	75.99		84	21	88	34	33.72	34	90	70.79 E
MKPH1	11/15/2016 19:15 HST	73.99		92	23	89	34	33.73	34	88	71.51 E
MKPH1	11/15/2016 20:15 HST	73.99		91	23	90	34.99	33.73	34.99	90	71.18 E
MKPH1	11/15/2016 21:15 HST	73.99		90	23	87	34	33.74	34	94	70.86 E
MKPH1	11/15/2016 22:15 HST	73.99		89	21	94	32.99	33.74	32.99	78	70.53 E
MKPH1	11/15/2016 23:15 HST	73.99		91	21	85	34	33.74	34	97	71.18 E
MKPH1	11/16/2016 00:15 HST	75		87	21	87	31	33.74	31	89	70.85 E
MKPH1	11/16/2016 01:15 HST	75		87	18.99	89	28.99	33.74	28.99	95	70.85 E
MKPH1	11/16/2016 02:15 HST	75.99		82	17	88	25.99	33.74	25.99	87	70.08 E
MKPH1	11/16/2016 03:15 HST	75.99		76	15.99	92	25.99	33.74	25.99	90	67.86 E
MKPH1	11/16/2016 04:15 HST	75.99		75	22.01	91	30	33.74	30	87	67.47 E
MKPH1	11/16/2016 05:15 HST	75.99		70	18.99	94	31	33.74	31	91	65.47 E
MKPH1	11/16/2016 06:15 HST	75.99		69	21	99	32.01	33.74	32.01	97	65.06 E
MKPH1	11/16/2016 08:15 HST	79		68	23	92	32.01	33.74	32.01	95	67.52 E

Figure 7 – List of observations from MKPH1 surrounding the accident time

MKPH1 weather at 1715 HST was reported as wind from 089° at 19.1 knots with gusts to 27.8 knots, temperature of 24.4° C, a dew point temperature of 21.0° C, and a station total precipitation accumulation of 33.72 inches.

MKPH1 weather at 1815 HST was reported as wind from 088° at 18.2 knots with gusts to 29.5 knots, temperature of 24.4° C, a dew point temperature of 21.6° C, and a station total precipitation accumulation of 33.72 inches.

MKPH1 weather at 1915 HST was reported as wind from 089° at 20.0 knots with gusts to 29.5 knots, temperature of 23.3° C, a dew point temperature of 22.0° C, and a station total precipitation accumulation of 33.73 inches.

The observations from PHMK indicated VFR⁴ conditions surrounding the accident time on the leeward side of the mountainous terrain with periods of rain and gusty surface winds from the east to northeast at PHMK, PAFH1, MLKH1, and MKPH1. Within the mountainous terrain at MLKH1 and PAFH1, the wind direction was much more variable as would be expected. The lines of rain showers moving from east to west across Molokai will be further described in section 5.4 along with the movement and location of the accident flight.

⁴ Visual Flight Rules – 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 6 miles visibility.

3.0 Upper Air Data

A Global Data Assimilation System (GDAS) model sounding was created for the accident site for 1700 HST. The 1700 HST sounding was plotted on a standard Skew-T log P diagram⁵ with the derived stability parameters included in figure 8 (with data from the surface to 600-hPa, or 14,000 feet msl.) This data was analyzed using the RAOB⁶ software package. The sounding depicted the lifted condensation level (LCL)⁷ at 2,553 feet, a convective condensation level (CCL)⁸ of 3,211 feet, and a level of free convection (LFC)⁹ at 2,678 feet. The freezing level was located at 15,533 feet. The precipitable water value was 1.07 inches.

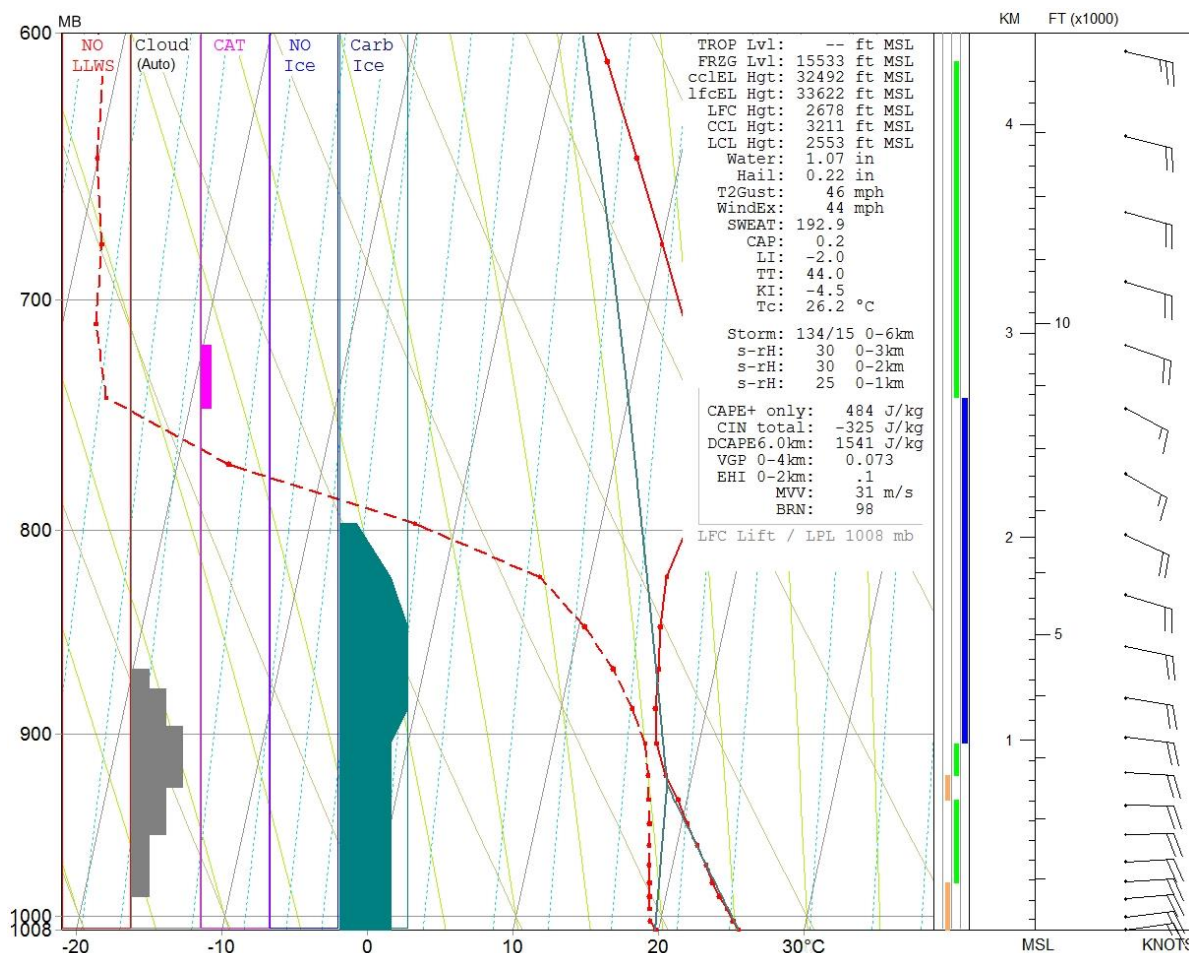


Figure 8 – 1700 HST GDAS sounding for the accident site

⁵ 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.

⁶ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

⁷ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

⁸ Convective Condensation Level (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.

⁹ Level of Free Convection (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.

The 1700 HST GDAS sounding indicated a mix of unstable and conditionally unstable layers between the surface and 3,000 feet with a stable layer between 3,000 and 9,000 feet. Given the trade winds¹⁰ (section 1.2) were the predominant weather determinant in the area of the accident site around the accident time, and the mountainous terrain and easterly upslope wind conditions (windward side of mountainous terrain), this environment would have been supportive of cloud formation and rain showers activity. 484 J/kg of CAPE¹¹ would have also supported the development of rain shower activity in the mountainous terrain with the maximum vertical velocity of the thunderstorm updrafts to 31 m/s or 60 knots. RAOB identified the possibility of clouds from 1,000 feet through 5,000 feet and this would have likely led to mountain obscuration conditions with rain shower activity on the windward slopes. No structural icing conditions were identified below 14,000 feet. RAOB identified the possibility of downdrafts coming out of the bottom of rain shower activity with wind gusts to 46 mph in the T2Gust parameter and wind gusts to 44 mph in the WindEx parameter.

The 1700 HST GDAS sounding wind profile indicated a surface wind from 082° at 17 knots with the wind remaining primarily easterly through 14,000 feet. The wind speed remained between 15 to 25 knots between the surface and 14,000 feet. RAOB indicated no possibility of low-level wind shear (LLWS) outside of rain shower activity with a small layer of clear-air turbulence between 9,000 and 10,000 feet.

4.0 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 NTSB's Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-15 band 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 1400 HST through 2200 HST at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

¹⁰ Trade wind – The wind system, occupying most of the Tropics, that blows from the subtropical highs toward the equatorial trough; a major component of the general circulation of the atmosphere. The winds are northeasterly in the Northern Hemisphere and southeasterly in the Southern Hemisphere; hence they are known as the northeast trades and southeast trades, respectively. The trade winds are best developed on the eastern and equatorial sides of the great subtropical highs, especially over the Atlantic. They are primarily surface winds, their usual depth being from 3000 to 5000 ft, although they sometimes extend to much greater altitudes. They are characterized by great constancy of direction and, to a lesser degree, speed; the trades are the most consistent wind system on earth.

¹¹ Convective Available Potential Energy (CAPE) – CAPE is a measure of the amount of energy available for convection and is directly related to the maximum potential vertical speed within an updraft.

Figures 9, 10, and 11 present the GOES-15 infrared imagery from 1830, 1845, and 1900 HST at 6X magnification with the accident site highlighted with a red square. The infrared imagery indicated relatively warm brightness temperatures throughout Hawaii, with the only areas of below freezing brightness temperatures near the highest mountain peaks of Hawaii (red colors). The cloud cover was moving from east to west across Hawaii (attachment 1) with the enhanced cloud cover associated with lines of rain shower activity (section 6.4). Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1700 HST GDAS sounding, the approximate cloud-top heights over the accident site were 9,000 feet at 1845 HST. It should be noted these figures have not been corrected for any parallax error.

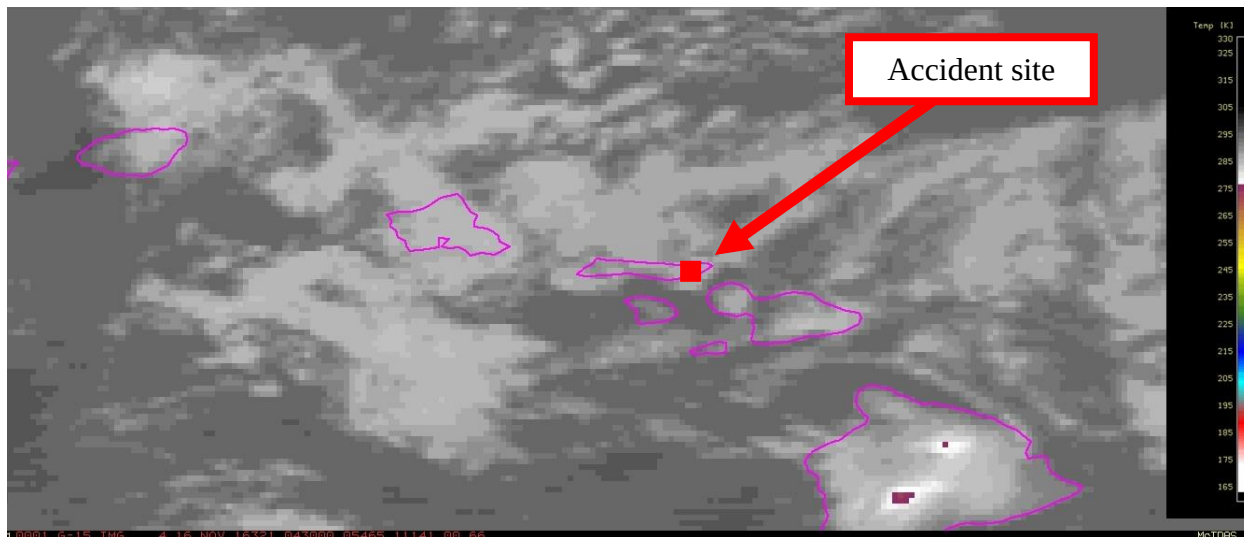


Figure 9 – GOES-15 infrared image at 1830 HST

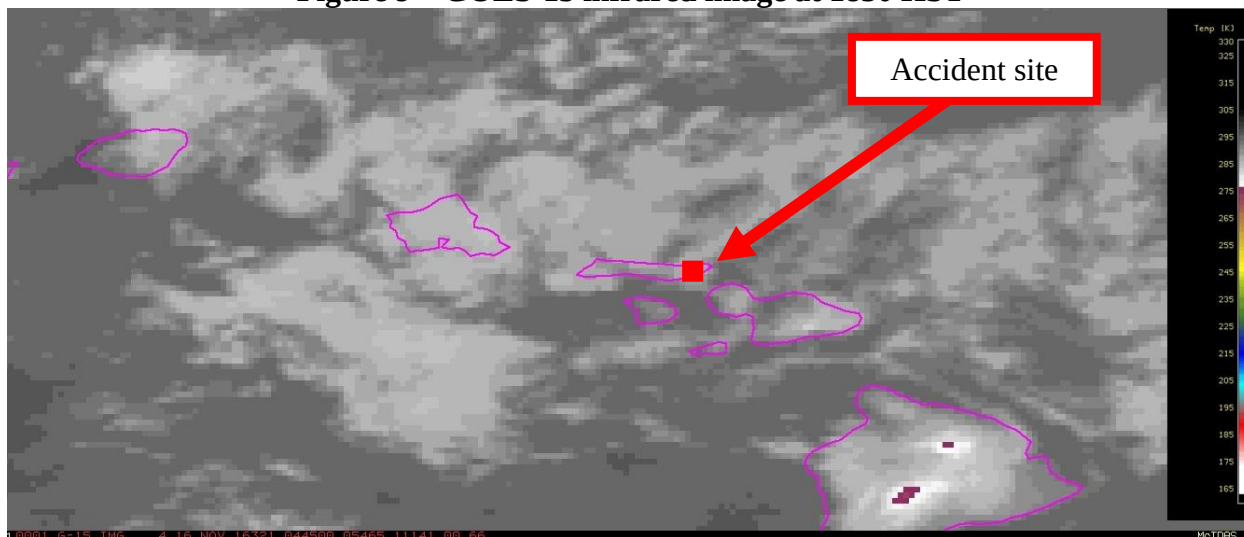


Figure 10 – GOES-15 infrared image at 1845 HST

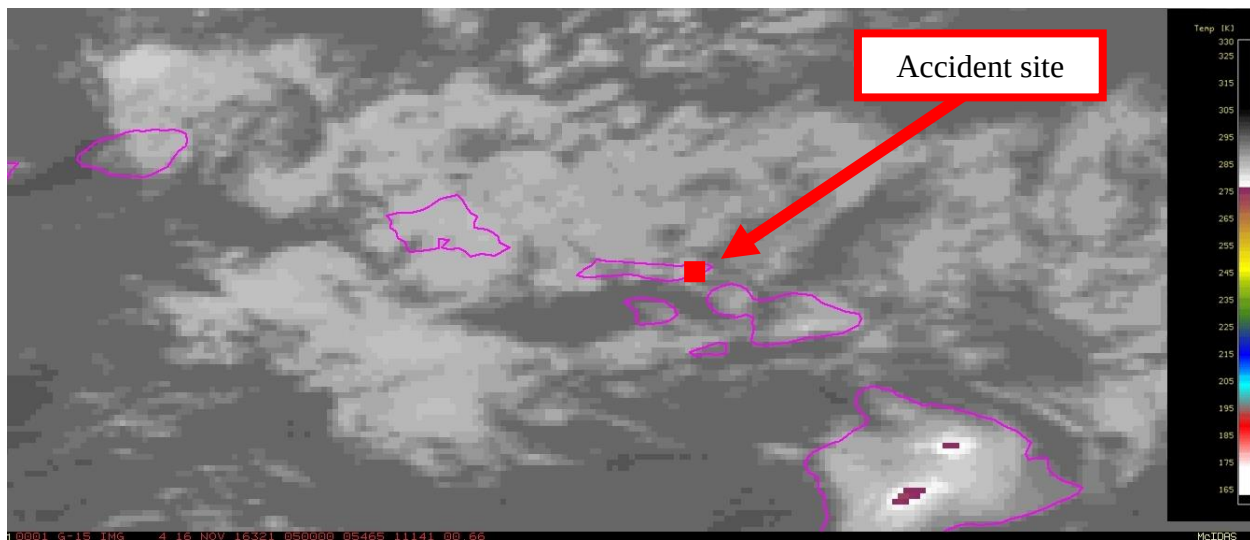


Figure 11 – GOES-15 infrared image at 1900 HST

5.0 Radar Imagery Information

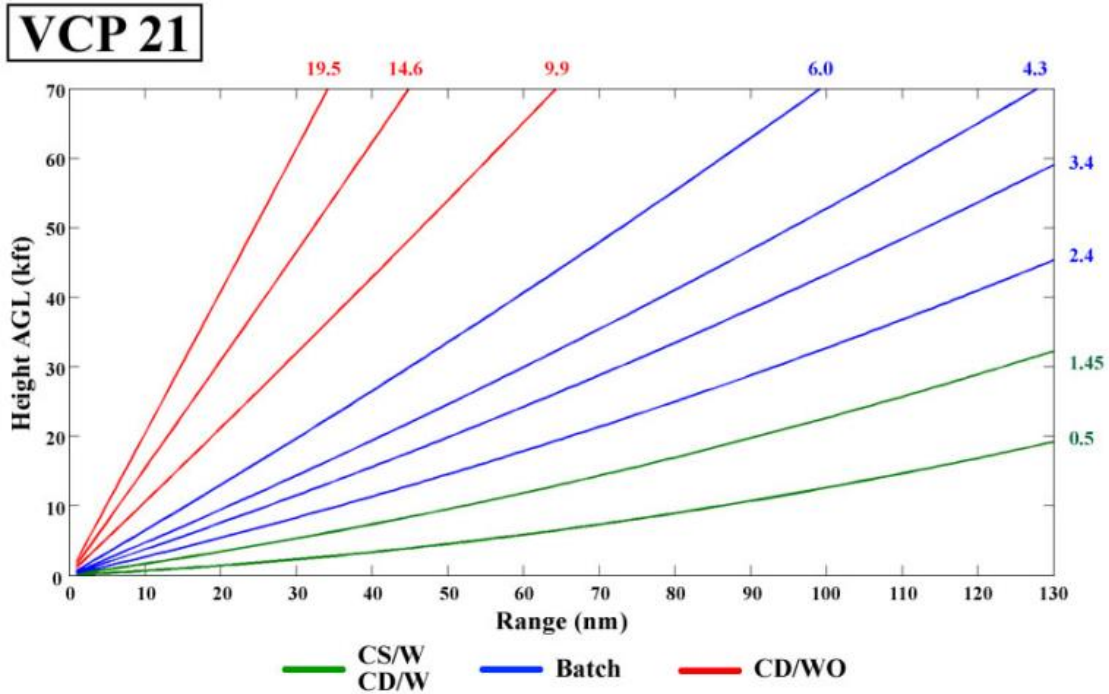
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹² to the accident site was the Molokai, Hawaii, radar (PHMO), which was located 22 miles west of the accident site at an elevation of 1,363 feet. Level II and III archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

5.1 Volume Scan Strategy

The WSR-88D is a computer-controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available on the WSR-88D's Principle Users Processor (PUP). Products that require data from multiple elevation scans are not available until the end of the five to ten minute volume scan.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 9 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten minute period. During the period surrounding the accident, the PHMO WSR-88D radar was operating in the precipitation mode (Mode A, VCP-21). The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.

¹² 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.



VCP-21 Precipitation Mode Scan Strategy¹³

5.2 Beam Height Calculation

Assuming standard refraction¹⁴ of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width¹⁵ information¹⁶ of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	2,870 feet	1,790 feet	3,960 feet	2,170 feet
1.5°	5,200 feet	4,120 feet	6,290 feet	2,170 feet

¹³ Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (PRF) scan of the split cut. Gives a high $R_{\max}$ value to determine proper target location and intensity, but a low $V_{\max}$ value limits the velocities that can be measured. Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low $R_{\max}$ value causing more range folded (multiple trip) echoes, but a high $V_{\max}$ value to get higher, more accurate velocity values.

Batch Mode – Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity. Used in the middle elevation angles.

W – With range unfolding (W)

WO – Without range unfolding (WO)

¹⁴ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

¹⁵ Beam width – A measure of the angular width of a radar beam.

¹⁶ Beamwidth values are shown for legacy resolution products. Super resolution products would have an effective beamwidth that would be approximately half these values.

Based on the radar height calculations, the 0.5° elevation scans depicted the conditions between 1,790 feet and 3,960 feet msl over the accident site and the 1.5° elevation scans depicted the conditions between 4,120 feet and 6,290 feet msl over the accident site. The 0.5° elevation scans are the closest altitudes to the accident site before the accident occurred, while the 1.5° elevation scans had much less weather radar beam blockage due to terrain over the accident site (than the 0.5° elevation scan).

5.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹⁷ it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ¹⁸), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C, “Thunderstorms,” dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be “light.” For dBZ values between 30 and 40, the terminology should be “moderate.” “Heavy” terminology is used for dBZ values greater than 40 dBZ but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

¹⁷ Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at the earth’s surface; also, any water particles blown by the wind from the earth’s surface. Hydrometeors are classified as; (a) Liquid or solid water particles suspended in the air: cloud, water droplets, mist or fog. (b) Liquid precipitation: drizzle and rain. (c) Freezing precipitation: freezing drizzle and freezing rain. (d) Solid (frozen) precipitation: ice pellets, hail, snow, snow pellets, and ice crystals. (e) Falling particles that evaporate before reaching the ground: virga. (f) Liquid or solid water particles lifted by the wind from the earth’s surface: drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glazed ice.

¹⁸ dBZ – A non-dimensional “unit” of radar reflectivity which represents a logarithmic power ratio (in decibels , or dB) with respect to radar reflectivity factor, Z.

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain.
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain.
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible.
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible.

5.4 Base Reflectivity and Lightning Data

Figures 12, 14, and 16 present the PHMO WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1834, 1839, and 1844 HST with a resolution of 0.5° X 250 m, while Figures 13, 15, and 17 present the PHMO WSR-88D base reflectivity images for the 1.5° elevation scans initiated at 1835, 1840, and 1845 HST with a resolution of 0.5° X 250 m. Base reflectivity values between 5 to 30 dBZ were located above the accident site around the accident time with these reflectivity values indicative of a line of rain showers with that line of rain showers moving over the accident site at the accident time (attachments 2 and 3). As the line of rain showers moved westward over the terrain that likely led to reduced visibilities and ceilings with instrument meteorological conditions likely near the mountainous terrain and mountain obscuration conditions (figures 18, 19, and 20, zoomed in images of figures 13, 15, and 17). There were no lightning strikes around the accident site at the accident time.¹⁹ The precipitation observed in the surface observations (section 2.0) matched the timing of the rain showers moving across Molokai Island (attachments 2 and 3) around the accident time.

¹⁹ A review of Earth Networks Total Lightning network was done.

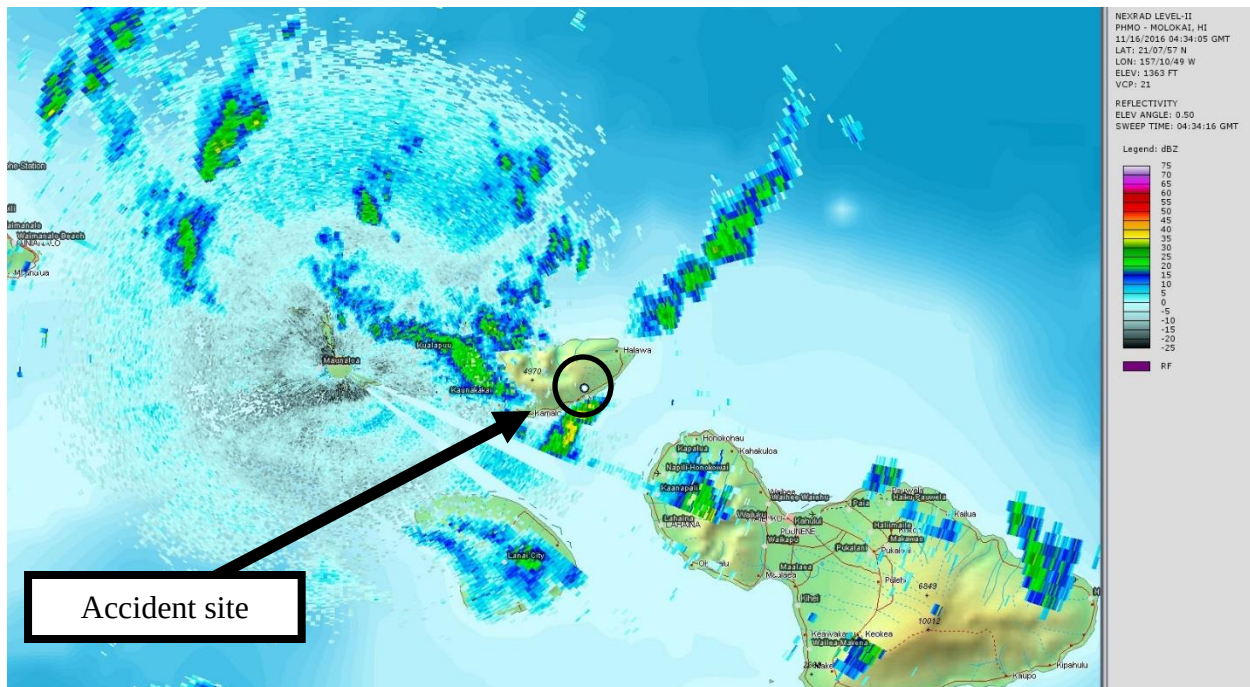


Figure 12 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1834 HST with the accident site marked with black circle

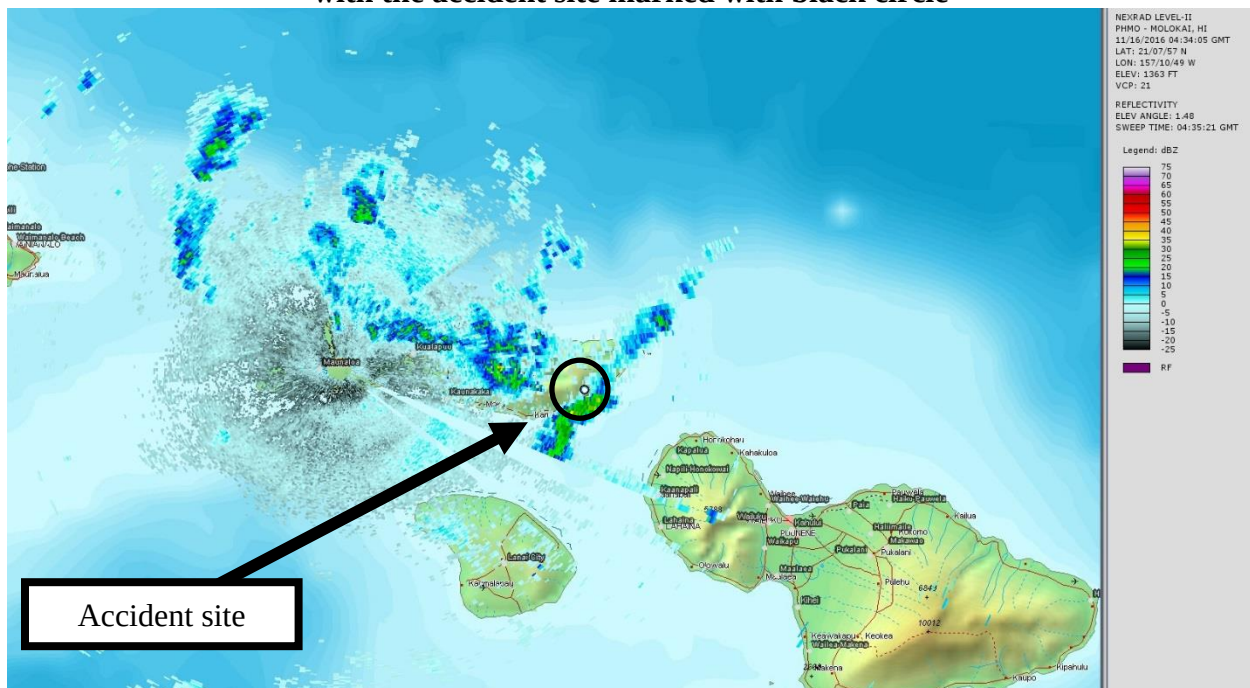


Figure 13 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1835 HST with the accident site marked with black circle

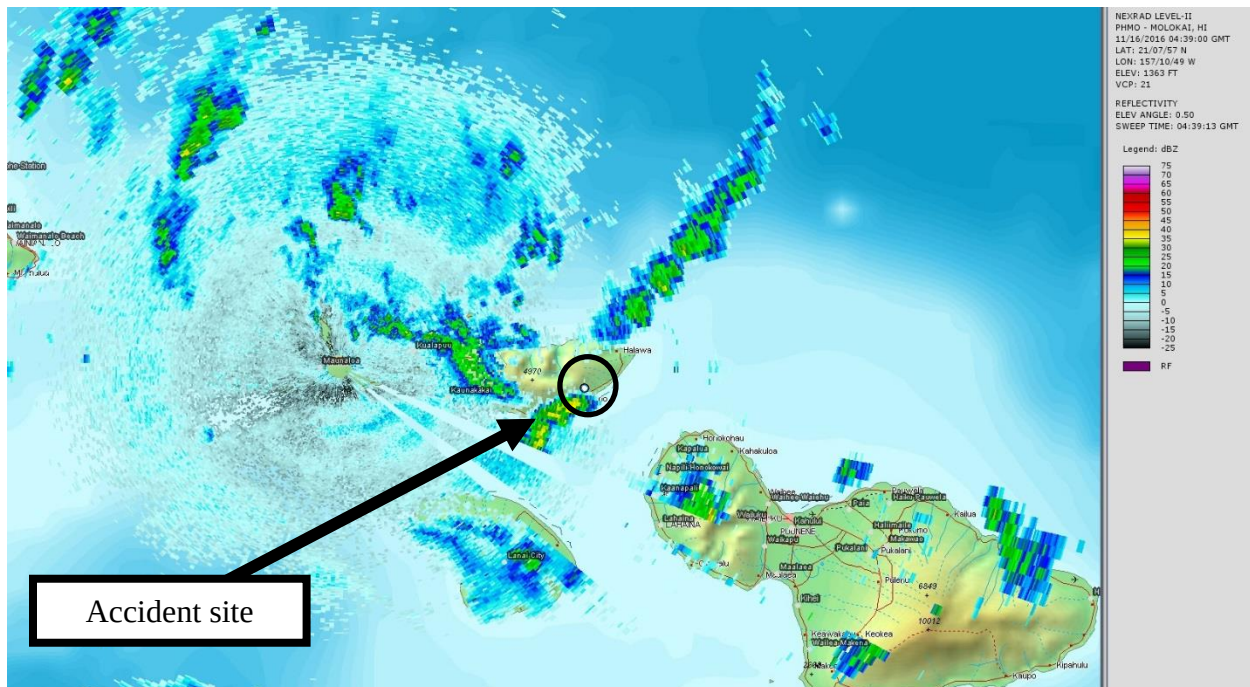


Figure 14 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1839 HST with the accident site marked with black circle

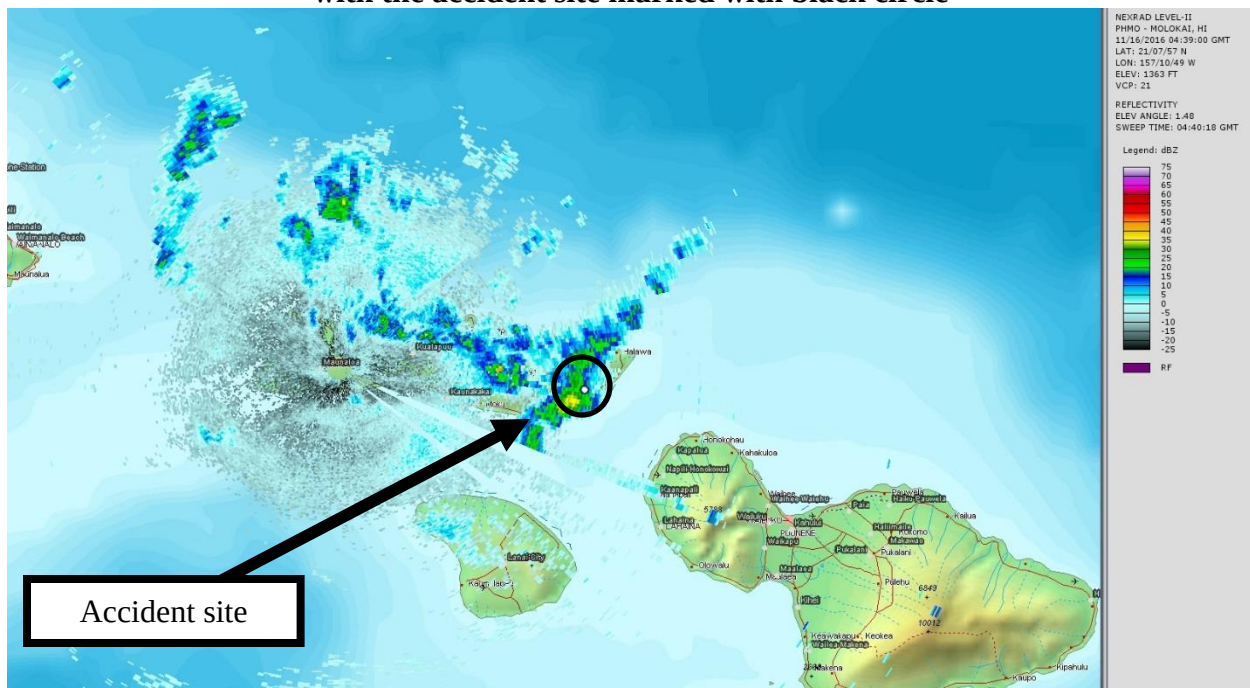


Figure 15 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1840 HST with the accident site marked with black circle

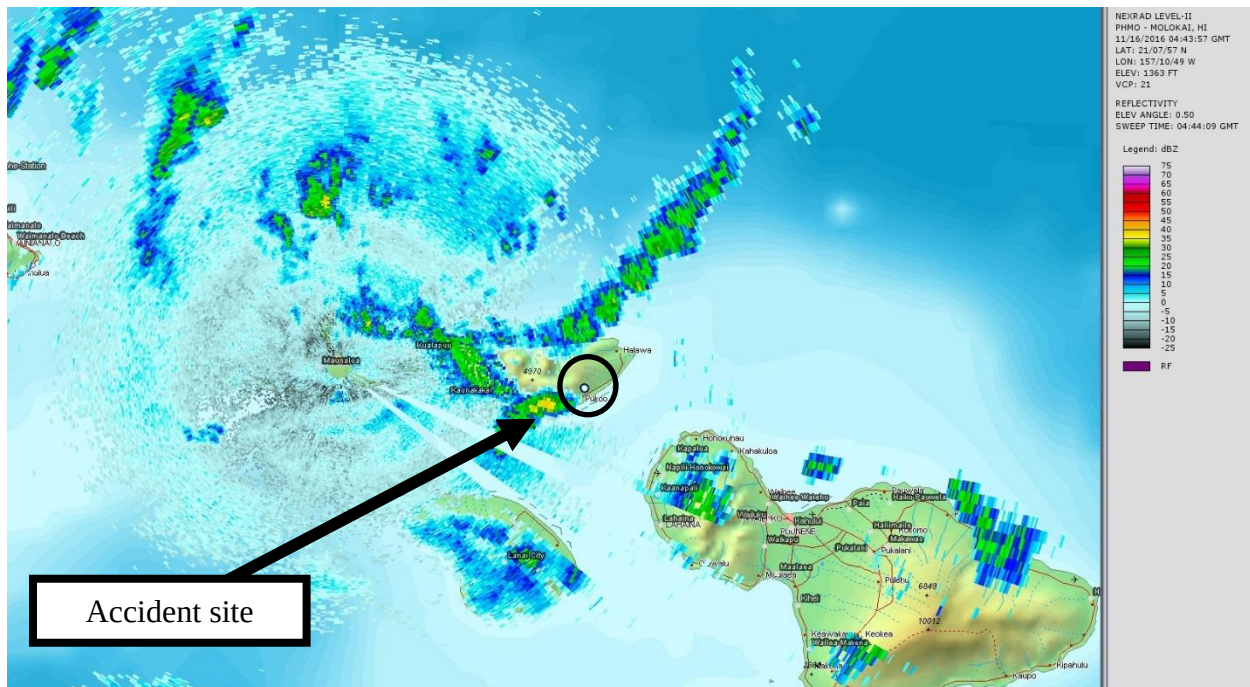


Figure 16 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1844 HST with the accident site marked with black circle

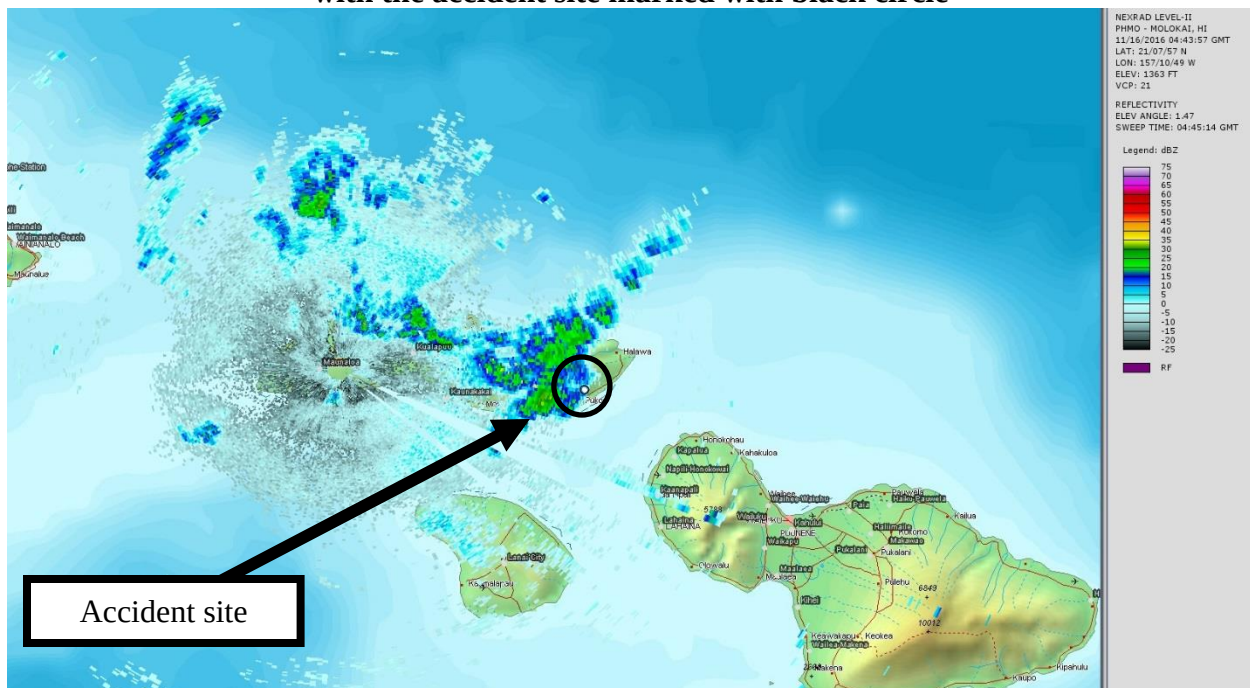


Figure 17 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1845 HST with the accident site marked with black circle

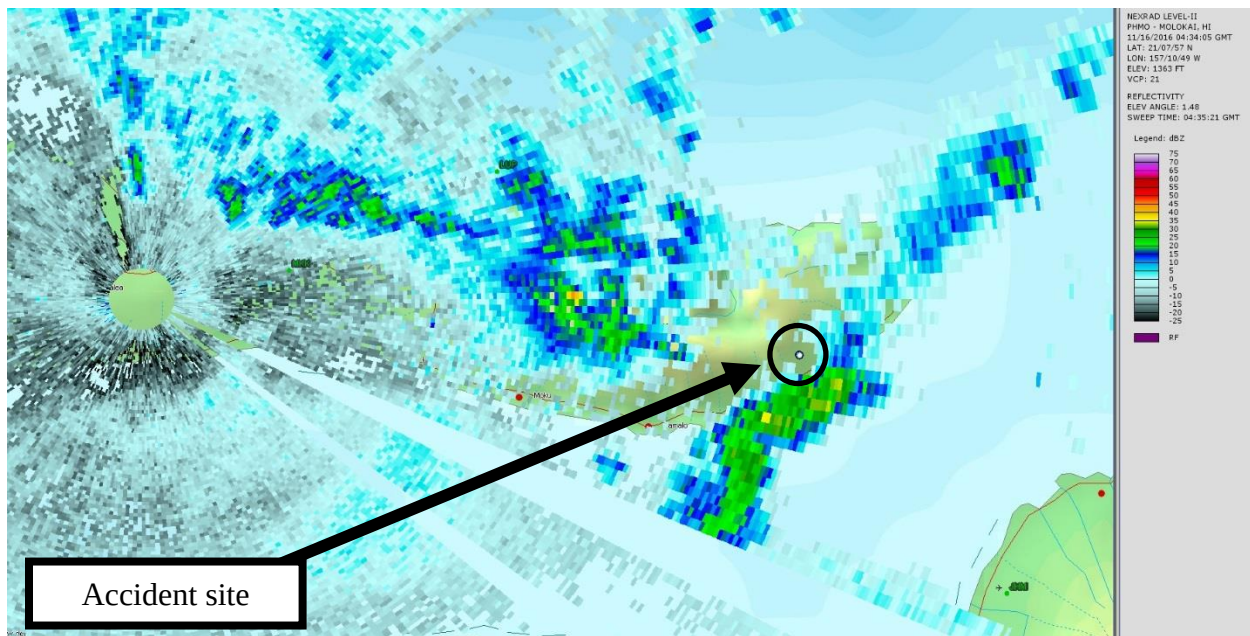


Figure 18 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1835 HST with the accident site marked with black circle zoomed in image

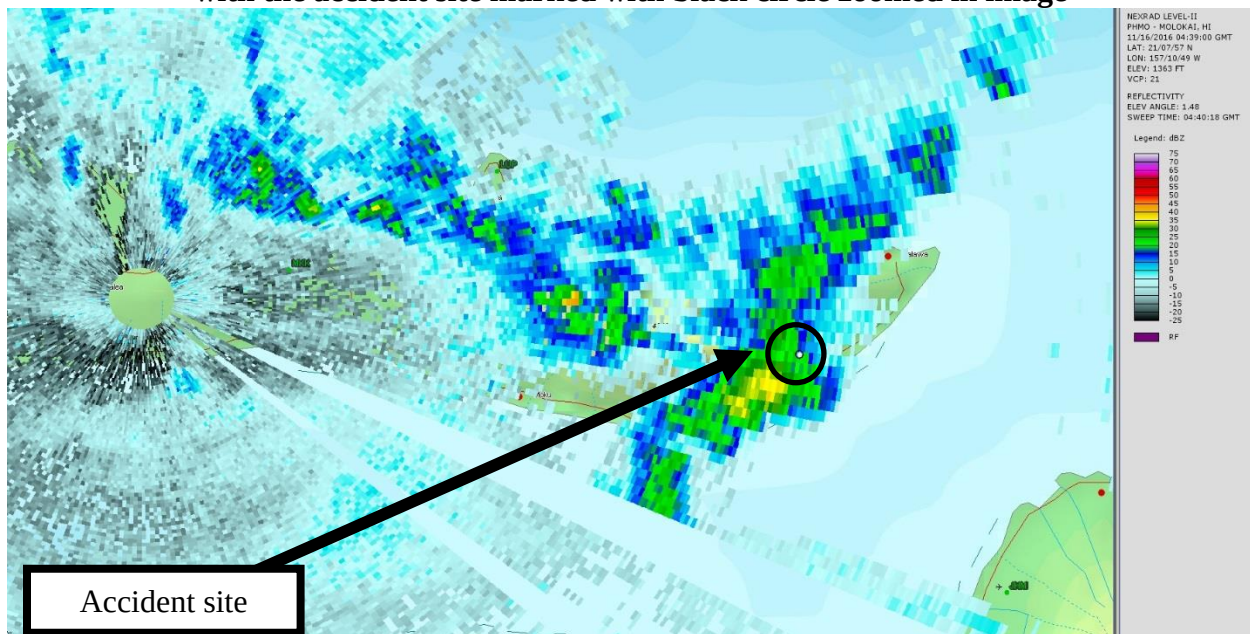


Figure 19 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1840 HST with the accident site marked with black circle zoomed in image

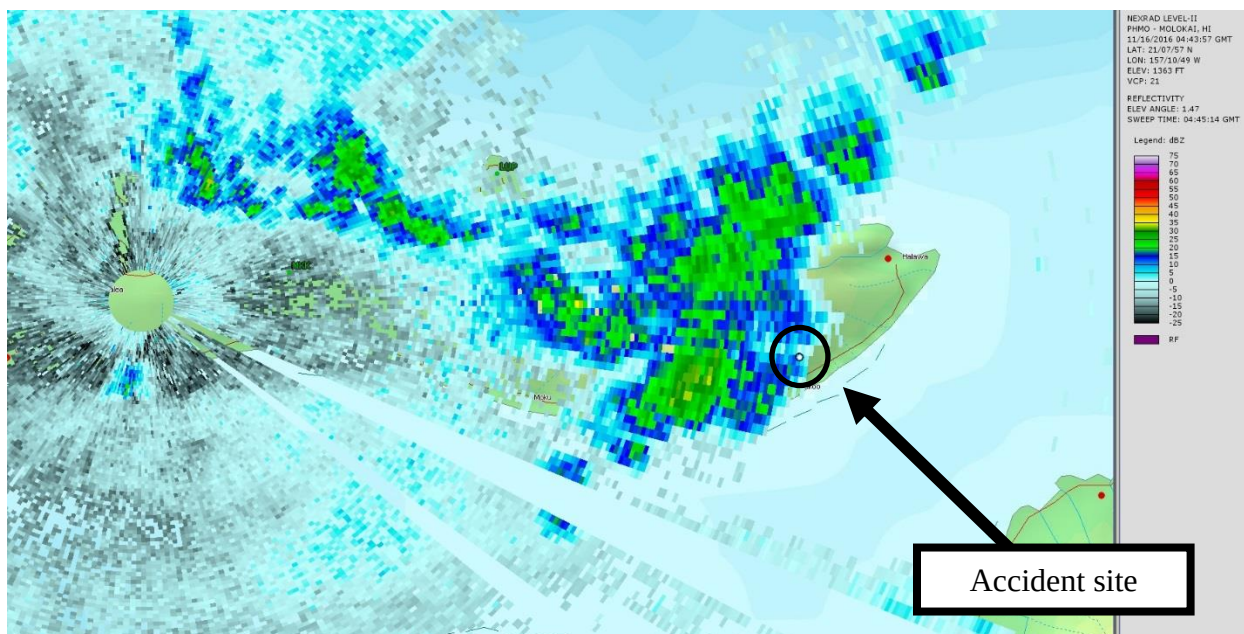


Figure 20 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1845 HST with the accident site marked with black circle zoomed in image

6.0 Pilot Reports

All pilot reports (PIREPs) close to the accident site from about three hours prior to the accident time to about three hours after the accident time for below FL250²⁰ are provided below:

OGG UUA /OV OGG 204001/TM 0233/FL004/TP B752/RM LLWS -15KT 400 FINAL RWY 2

HNL UA /OV 8 MI SE HNL/TM 0422/FL055/TP B717/SK 025 BKN=

Urgent pilot report (UUA); Over 1 mile from Kahului, Hawaii, on the 204° radial; Time – 1633 HST (0233Z on November 16); Altitude – 400 feet; Type aircraft – Boeing B757-200; Remarks – LLWS loss of 15 knots at 400 feet on final for runway 2.

Routine pilot report (UA); Over 8 miles southeast of Honolulu, Hawaii; Time – 1822 HST (0422 on November 16); Altitude – 5,500 feet; Type aircraft – Boeing B717; Sky – Broken ceiling at 2,500 feet msl.

7.0 SIGMET and CWSU Advisory

There were no SIGMETs valid for the accident site at the accident time.

²⁰ Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of feet. 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.

There were no Center Weather Service Unit (CWSU) Meteorological Impact Statements (MIS)s that were valid for the accident site at the accident time. No CWSU Advisories (CWA)s were valid for the accident site at the accident time.

8.0 AIRMETs

AIRMET Sierra was issued at 1731 HST and valid at the accident time for the accident site. AIRMET Sierra warned of mountain obscuration on the north through east facing slopes of Molokai due to clouds and rain showers. Temporary conditions of ceilings around 2,500 feet msl were forecast. The previous AIRMET Sierra was also valid before the accident flight departure with the previous AIRMET Sierra issued at 1650 HST:

WAHW31 PHFO 160331

WA0HI

HNLS WA 160400

AIRMET SIERRA FOR IFR VALID UNTIL 161000

.

AIRMET MTN OBSC...BIG ISLAND.

CANCEL AIRMET. CONDS HAVE IMPROVED.

.

AIRMET MTN OBSC...MAUI MOLOKAI OAHU

N THRU E FACING SLOPES.

MTN TEMPO OBSC ABV 025 EXP DUE TO CLD AND SHRA.

COND CONT BEYOND 1000Z.

=HNLT WA 160400

AIRMET TANGO FOR TURB VALID UNTIL 161000

.

AIRMET TURB...HI

OVER AND IMT S THRU W OF MTN.

TEMPO MOD TURB BLW 080. COND CONT BEYOND 1000Z.

=HNLZ WA 160400

AIRMET ZULU FOR ICE AND FZLVL VALID UNTIL 161000

.

NO SIGNIFICANT ICE EXP.

.

FZLVL...150-160.

WAHW31 PHFO 160250

WA0HI

HNLS WA 160250 AMD

AIRMET SIERRA UPDATE 6 FOR IFR VALID UNTIL 160400

.

AIRMET MTN OBSC...BIG ISLAND.

UPOLU POINT TO VOLCANO.

MTN TEMPO OBSC ABV 025 EXP DUE TO CLD AND SHRA.

COND END BY 0400Z.

.

AIRMET MTN OBSC...MAUI MOLOKAI

N THRU E FACING SLOPES.

MTN TEMPO OBSC ABV 025 EXP DUE TO CLD AND SHRA.

COND CONT BEYOND 0400Z.

=HNLZ WA 152200
 AIRMET TANGO UPDATE 3 FOR TURB VALID UNTIL 160400
 .
 AIRMET TURB...HI
 OVER AND IMT S THRU W OF MTN.
 TEMPO MOD TURB BLW 070. COND CONT BEYOND 0400Z.
 =HNLZ WA 152200
 AIRMET ZULU UPDATE 3 FOR ICE AND FZLVL VALID UNTIL 160400
 .
 NO SIGNIFICANT ICE EXP.
 .
 FZLVL...163 PHLI SLOPING TO 149 PHTO.

9.0 Area Forecast

The Area Forecast issued at 1734 HST, valid at the accident time, forecasted scattered clouds at 2,500 feet with scattered to a broken ceiling at 5,000 feet with tops to 7,000 feet. Temporary conditions of broken ceilings at 2,500 feet with tops to 9,000 feet and visibilities between 3 and 5 miles with rain showers were also forecast with isolated broken ceilings at 1,500 feet with visibilities below 3 miles in rain showers. Similar conditions were forecast in the 1143 HST Area Forecast for Molokai:

FAHW31 PHFO 160334
 FA0HI
 HNLC FA 160335
 SYNOPSIS AND VFR CLD/WX
 SYNOPSIS VALID UNTIL 162200
 CLD/WX VALID UNTIL 161600...OUTLOOK VALID 161600-162200
 .
 SEE AIRMET SIERRA FOR IFR CLD AND MTN OBSC.
 TS IMPLY SEV OR GREATER TURB SEV ICE LOW LEVEL WS AND IFR COND.
 NON MSL HGT INDICATED BY AGL OR CEILING.
 .
 SYNOPSIS...STRONG SFC HIGH FAR NNE OF ISLANDS MOVING E 20 KT.
 GUSTY TRADE WINDS TO PREVAIL.
 .
 BIG ISLAND LOWER SLOPES...COAST...AND ADJ WATERS FROM UPOLU POINT
 TO CAPE KUMUKAHI TO APUA POINT.
 SCT025 SCT-BKN050 TOPS 080 TEMPO OVC050 TOPS 100 ISOL BKN020
 TOPS 120 VIS 3-5SM SHRA. OUTLOOK...VFR.
 .
 BIG ISLAND LOWER SLOPES...COAST...AND ADJ WATERS FROM APUA POINT
 TO SOUTH CAPE TO PHKO TO UPOLU POINT.
 FEW-SCT030 SCT-BKN050 TOPS 080 ISOL BKN030 OVC050 VIS 5SM -SHRA.
 06Z FEW025 SCT050 ISOL BKN050 TOPS 090. OUTLOOK...VFR.
 .
**MTN...N THRU E SECTIONS...AND ADJ WATERS OF OAHU MOLOKAI
 AND MAUI.**
**SCT025 SCT-BKN050 TOPS 070 TEMPO BKN025 TOPS 090 VIS 3-5SM SHRA
 ISOL BKN015 VIS BLW 3SM SHRA. OUTLOOK...VFR.**
 .
 MTN...N THRU E SECTIONS AND ADJ WATERS OF KAUAI.
 SCT025 BKN-OVC050 TOPS 070 ISOL BKN025 VIS 3-5SM SHRA. 09Z SCT025
 SCT-BKN050 TOPS 070 TEMPO BKN025 TOPS 090 VIS 3-5SM SHRA ISOL

BKN015 VIS BLW 3SM SHRA. OUTLOOK...VFR.

.

REST OF AREA.

FEW-SCT025 SCT-BKN050 TOPS 070 ISOL -SHRA. OUTLOOK...VFR.

FAHW31 PHFO 152143

FA0HI

HNLC FA 152135

SYNOPSIS AND VFR CLD/WX

SYNOPSIS VALID UNTIL 161600

CLD/WX VALID UNTIL 161000...OUTLOOK VALID 161000-161600

.

SEE AIRMET SIERRA FOR IFR CLD AND MTN OBSC.

TS IMPLY SEV OR GREATER TURB SEV ICE LOW LEVEL WS AND IFR COND.

NON MSL HGT INDICATED BY AGL OR CEILING.

.

SYNOPSIS...STRONG SFC HIGH FAR NNE OF ISLANDS MOVING E 20 KT.

GUSTY TRADE WINDS TO PREVAIL.

.

BIG ISLAND LOWER SLOPES...COAST...AND ADJ WATERS FROM UPOLU POINT TO CAPE KUMUKAHI TO APUA POINT.

FEW005 SCT025 BKN-OVC050 TOPS 080 -SHRA TEMPO SCT005 BKN025

TOPS 100 VIS 3-5SM SHRA BR ISOL BKN015 TOPS 120 VIS BLW 3SM SHRA.

OUTLOOK...MVFR CIG VIS.

.

BIG ISLAND LOWER SLOPES...COAST...AND ADJ WATERS FROM APUA POINT TO SOUTH CAPE TO PHKO TO UPOLU POINT.

FEW-SCT030 SCT-BKN050 TOPS 080 ISOL BKN030 OVC050 VIS 5SM -SHRA.

OUTLOOK...VFR.

.

MTN...N THRU E SECTIONS...AND ADJ WATERS OF KAUAI OAHU MOLOKAI AND MAUI.

SCT025 SCT-BKN050 TOPS 070 TEMPO -SHRA ISOL BKN025 TOPS 090

VIS 3-5SM SHRA. OUTLOOK...VFR.

.

REST OF AREA.

FEW-SCT025 SCT050 ISOL BKN050 TOPS 080 -SHRA. OUTLOOK...VFR.

10.0 Terminal Aerodrome Forecast

PHMK was the closest site to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The TAF valid at the time of the accident was issued at 1328 HST and was valid for a 24-hour period beginning at 1400 HST. The TAF for PHMK was as follows:

TAF PHMK 152328Z 1600/1624 05016G24KT P6SM FEW030 SCT050

FM160400 05010G18KT P6SM VCSH SCT025 BKN050

FM162000 06014G20KT P6SM VCSH SCT030 BKN050=

The forecast expected a wind from 050° at 10 knots with gusts to 18 knots, greater than 6 miles visibility, vicinity²¹ showers, scattered clouds at 2,500 feet agl, and a broken ceiling at 5,000 feet agl.

11.0 NWS Area Forecast Discussion

The NWS Office in Honolulu, Hawaii, issued the following Area Forecast Discussion (AFD) at 1604 HST (closest AFD to the accident time). The aviation section of the AFD discussed that showery conditions were occurring in the trade wind flow across Hawaii, which were resulting in some MVFR²² conditions. The rain showers and gusty trade winds near the mountains terrain were the reason for the AIRMET Sierra and AIRMET Tango valid at the accident time:

320
FXHW60 PHFO 160204
AFDHFO

Area Forecast Discussion
National Weather Service Honolulu HI
404 PM HST Tue Nov 15 2016

.SYNOPSIS...

Breezy trade winds, with slight deviations, will continue for at least the next week due to progressive high pressure systems passing north of the state. Low clouds and showers will affect mainly windward and mountain areas, especially during nights and mornings. Clouds and showers from an old front will move through the island chain this weekend.

&&

.DISCUSSION...

A 1033 mb surface high is located far north northeast of Hawaii and driving fresh trade winds. Visible satellite and radar shows clouds and light showers moving in with the trades impacting mainly the windward areas from the Big Island to Oahu late this afternoon. Strong midlevel ridging across the state is providing stable atmospheric conditions. 00Z soundings show inversions around 6 kft at Lihue to near 9 kft at Hilo with precipitable water (PW) values of 1 inch and 1.34 inches respectively. MIMIC layered PW satellite imagery confirms these values, with the higher PW values tracking westward tonight.

The high to the northeast will track eastward while a front currently 900 miles to the northwest weakens and dissipates. The front will result in a brief weakening in the trade wind flow through Wednesday night. The trade winds will bring in a few showers across windward and mauka areas over the next couple of days, mainly at night and early in the morning. Showers will be

²¹ In the vicinity of the airport is defined as a weather phenomenon within 5-10 miles of the airfield, but not over the airfield.

²² Marginal Visual Flight Rules – 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 and/or 3 to 5 miles visibility.

fairly uniform across the islands tonight, with likely a shift to the windward and southeast Big Island Wednesday night. Models are picking up on some moisture skirting past and to the south of the Big Island. That being said, rainfall amounts are likely to be on the lighter side given the stability.

A new high will quickly build far northwest of the islands Thursday, strengthening and turning the winds to the northeast. Moisture associated with the earlier mentioned dissipated front northwest of the islands will move over us late Friday night. The moisture axis will then move southward down the island chain this weekend. Showers are expected to increase along the axis but will be carried westward by the breezy trades. This means most of the showers will focus over windward areas, but leeward sides of the smaller islands will likely get some passing showers too. Winds are expected to weaken slightly and veer to the east southeast late in the weekend and early next week as the high moves northeast of the state.

&&

.AVIATION...

An area of showery low clouds moving toward the islands in the trade wind flow is expected to continue to promote the development of MVFR VIS/CIG over windward portions of the Big Island into the evening, with periods of IFR VIS possible. While these showery low clouds may clear the Big Island later this evening, they extend about 500 miles NE from the Big Island, and appear poised to move ashore over windward portions of the smaller islands overnight.

Clouds are also developing between the islands and these showers, and the trade wind flow is trending wetter. Therefore, expect increasing SHRA leading to more widespread MVFR VIS/CIG over windward portions of the islands from Maui to Kauai. AIRMET SIERRA for mountain obscuration is posted for windward Big Island, and may need to be expanded to additional areas. AIRMET TANGO for low level mechanical turbulence to the S through W of the mountains will continue through at least tonight, due to locally strong trade winds.

At the TAF sites, some improvement to the persistent MVFR/IFR conditions is expected later this evening at PHTO as the aforementioned area of SHRA clears the island. While -SHRA may affect some of the leeward TAF sites like PHMK and PHNL, VFR will prevail. MVFR conditions are possible at windward locations like PHLI, and possibly PHOG.

&&

.MARINE...

The High Surf Advisory in effect for north and west facing shores of the smaller islands has been cancelled as the northwest swell has declined.

A new north swell is expected Wednesday, with expected peak surf heights well below advisory levels. A north northwest swell on

Friday is expected to produce advisory-level surf along north facing shores before diminishing over the weekend.

High pressure northeast of the state is supporting fresh to locally strong easterly trade winds over the waters. These winds will produce choppy conditions along east facings shores through much of the forecast period, but surf heights are likely to keep below advisory conditions. The Small Craft Advisory (SCA) has been dropped for several coastal water zones as the swell has declined, however it remains in effect through Wednesday for areas most exposed to the winds. See zones affected by the SCA below.

Winds will back to the northeast and strengthen slightly on Thursday and maintain through the weekend as the high to the northeast fades and a new one builds in northwest of the state.

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.HFO WATCHES/WARNINGS/ADVISORIES...

Small Craft Advisory until 6 PM HST Wednesday for Oahu Windward Waters-Kaiwi Channel-Maui County Windward Waters-Maui County Leeward Waters-Maalaea Bay-Pailolo Channel-Alenuihaha Channel-Big Island Leeward Waters-Big Island Southeast Waters.

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DISCUSSION/MARINE...Foster
AVIATION...Birchard

12.0 Winds and Temperature Aloft Forecast

The NWS 1559 HST Winds and Temperature Aloft forecast valid for the accident flight is included below:

```
321
FBHW31 KWN0 160159
FD1HW1
-DATE BASED ON 160000Z
VALID 160600Z   FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT  1000 1500 2000 3000      6000      9000      12000      15000      18000      24000

-LIH 0814 0817 0921 1023 1216+12 1121+14 1122+08 1122+01 1124-08 1034-20
-HNL 0819 0823 0927 1030 1115+12 1026+13 1025+08 1025+02 1124-09 1036-21
-LNY          0926 1026 1019+14 0923+14 1027+08 1026+02 1026-09 1038-21
-OGG 0924 0927 0930 1034 1020+15 1024+14 1026+08 1027+01 1029-09 1039-21
-KOA 9900 9900 9900 2105 9900+14 0813+12 0924+09 1028+02 1025-09 0938-21
-ITO 9900 9900 0805 1116 0915+10 0924+14 1027+09 1028+01 0926-09 0940-21
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The accident site was between the forecast point at Kahului, Hawaii, (OGG), and the forecast point at Lanai City, Hawaii, (LNY). The 1559 HST OGG forecast indicated a wind from 090° at 24 knots at 1,000 feet, a wind from 090° at 27 knots at 1,500 feet, a wind from 090° at 30 knots at 2,000 feet, a wind from 100° at 34 knots at 3,000 feet, and a wind from 100° at 20 knots with a temperature of 15° C at 6,000 feet. The 1559 HST LNY forecast indicated a wind from 090° at 26 knots at 2,000 feet, a wind from 100° at 26 knots at 3,000 feet, and a wind from 100° at 19 knots with a temperature of 14° C at 6,000 feet.

13.0 Pilot Weather Briefing and Witness Information

A search of official weather briefing sources, such as Lockheed Martin Flight Service and Direct User Access Terminal Service revealed that the accident pilot did not request an official weather briefing. It is unknown what if any other weather information the accident pilot checked before the accident flight.

A witness 2 miles from the accident site saw the accident aircraft flying “surprising low” while approaching the intended destination location just before the accident time. The witness reported the weather as very windy with clouds and rain higher up on the mountain. An additional witness at that location mentioned they believed it was raining when they saw accident aircraft approaching from the southwest.²³

A witness 1 mile southeast of the accident site noted the weather at the time of the accident as very windy and rain, “as bad as I’ve ever seen it.” The witness also noted that when the search light from the accident aircraft briefly went past their residence shortly before the accident time, that the rain was falling at a 45 degree to 90-degree angle to the ground.

14.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on November 15, 2016, indicated the following:

SUN	
Begin civil twilight	0615 HST
Sunrise	0638 HST
Sun transit	1212 HST
Sunset	1746 HST
End civil twilight	1809 HST

²³ For more information see Witness Statements and Interview Summaries contained in the docket for this accident.

MOON

Moonrise	1828 HST on preceding day
Moon transit	0108 HST
Moonset	0751 HST
Moonrise	1925 HST

The phase of the Moon was Waning Gibbous with 97% of the Moon's visible disk illuminated. The Moon had not yet risen after the end of civil twilight and with the accident time of 1841 HST.

F. LIST OF ATTACHMENTS

Attachment 1 – GOES-15 infrared satellite animation from 1730 to 1900 HST

Attachment 2 – PHMO WSR-88D reflectivity for the 0.5° elevation scan animation from 1730 to 1904 HST

Attachment 3 – PHMO WSR-88D reflectivity for the 1.5° elevation scan animation from 1731 to 1905 HST

Submitted by:

Paul Suffern
Senior Meteorologist

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