National Transportation Safety Board
Office of Aviation Safety
Washington, DC 20594

DCA22MA193

METEOROLOGY

Specialist's Factual Report

December 6, 2022

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A. ACCIDENT

Location:	Mutiny Bay near Freeland, Washington
Date:	September 4, 2022
Time:	1509 Pacific daylight time 2209 coordinated universal time (UTC)
Airplane:	de Havilland DHC-3; Registration: N725TH

B. METEOROLOGY SPECIALIST

Specialist	Paul Suffern National Transportation Safety Board Washington, DC

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's Senior Meteorologist did not travel for this investigation, but gathered all data remotely. Additional data for this investigation was collected from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). This Specialist's Factual Report contains the meteorological factors pertinent to the weather surrounding the accident time. All times are Pacific daylight time (PDT) and are based upon the 24-hour clock, where local time is -7 hours from UTC. Directions are referenced to true north and distances are in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles. NWS station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports.

The accident site was located at approximate latitude 47.99032° N, longitude 122.58502° W, at sea-level.

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 WPC, 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]

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart centered over the northwestern United States for 1400 PDT is provided as figure 1 with the location of the accident site within the black circle. The chart depicted a low-pressure system over southeastern Vancouver Island at 1016-hectopascal (hPa) with a cold front extending southwestward over western Washington into the Pacific Ocean. Another low-pressure system at 1012-hPa was located in northcentral Washington with a trough[2] extending north and south of the low across central Washington.

The station model closest to the accident site depicted air temperatures of the low 70s Fahrenheit (°F), dew point temperature of 56°F, mostly clear skies, and a variable wind under 10 knots.

[1] https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235

[2] Trough – An elongated area of relatively low atmospheric pressure or heights.

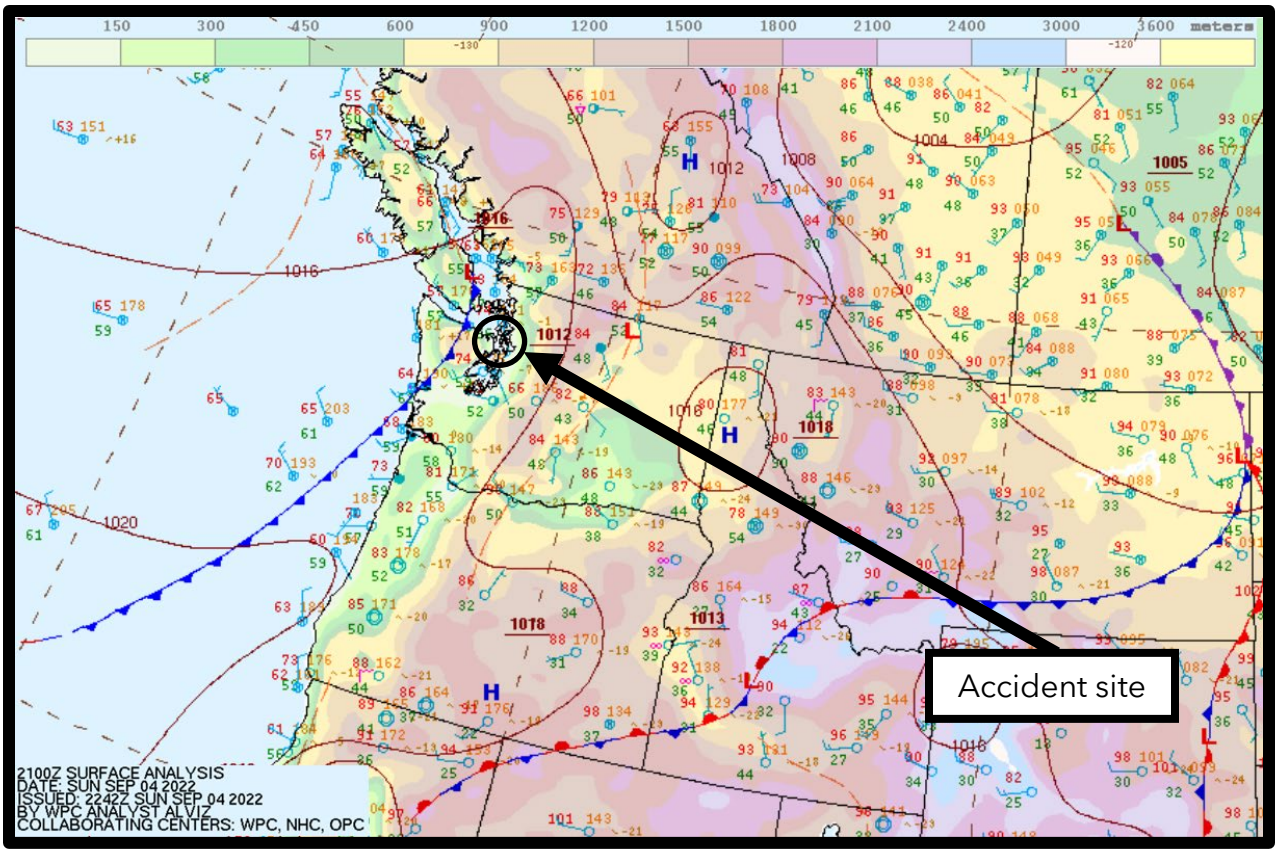

Figure 1. NWS Surface Analysis Chart for 1400 PDT.

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1700 PDT at 850-, 700-, and 500-hPa are presented in figures 2, 3, and 4. The accident site was located just east of a low- and mid-level trough. Troughs and fronts can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. The 850-hPa constant pressure chart depicted a northwest wind of 10 to 15 knots near the accident site (figure 2) with the wind becoming westerly by 500-hPa. The wind speed increased to 65 knots by 500-hPa (figure 4).

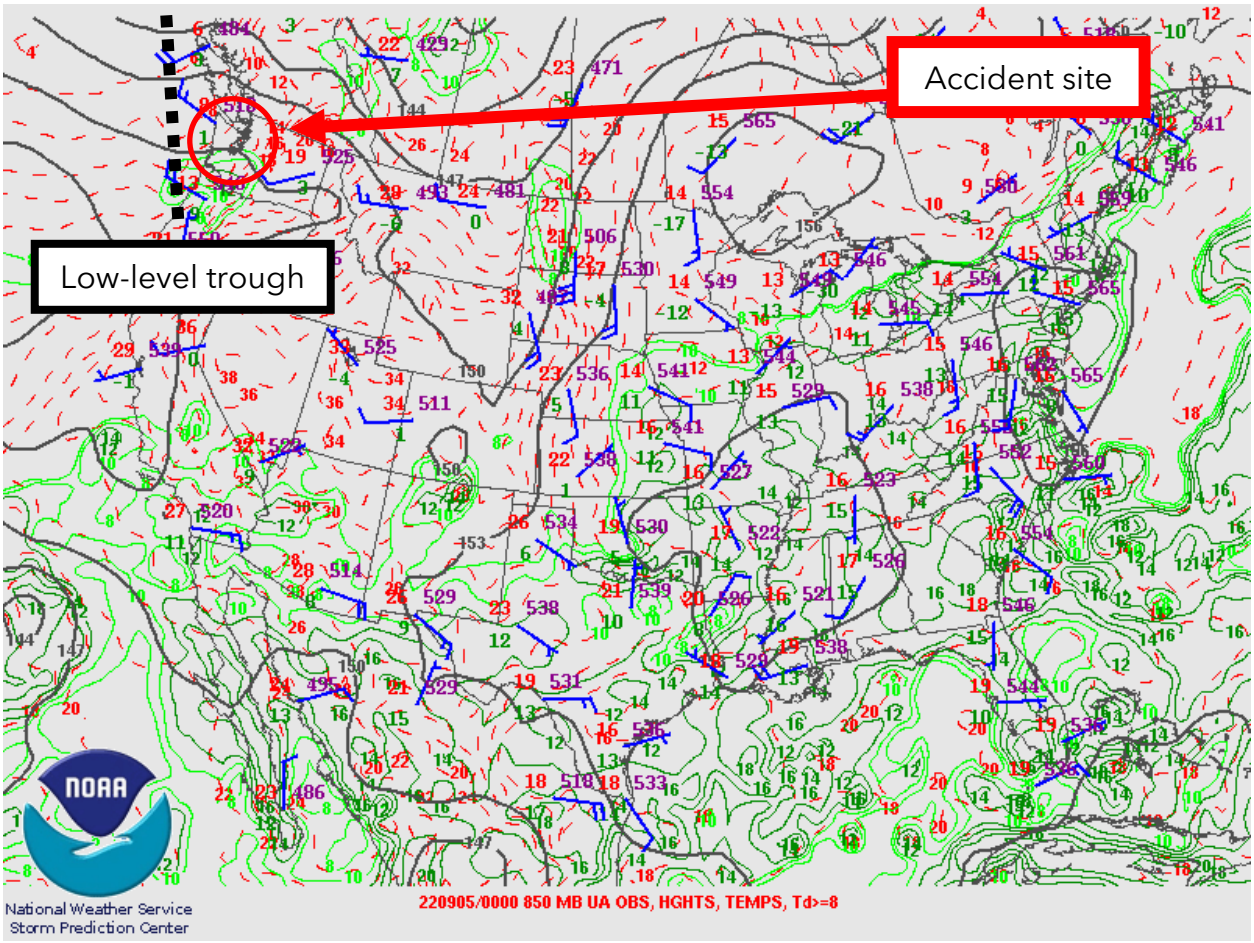

Figure 2. 850-hPa Constant Pressure Chart for 1700 PDT.

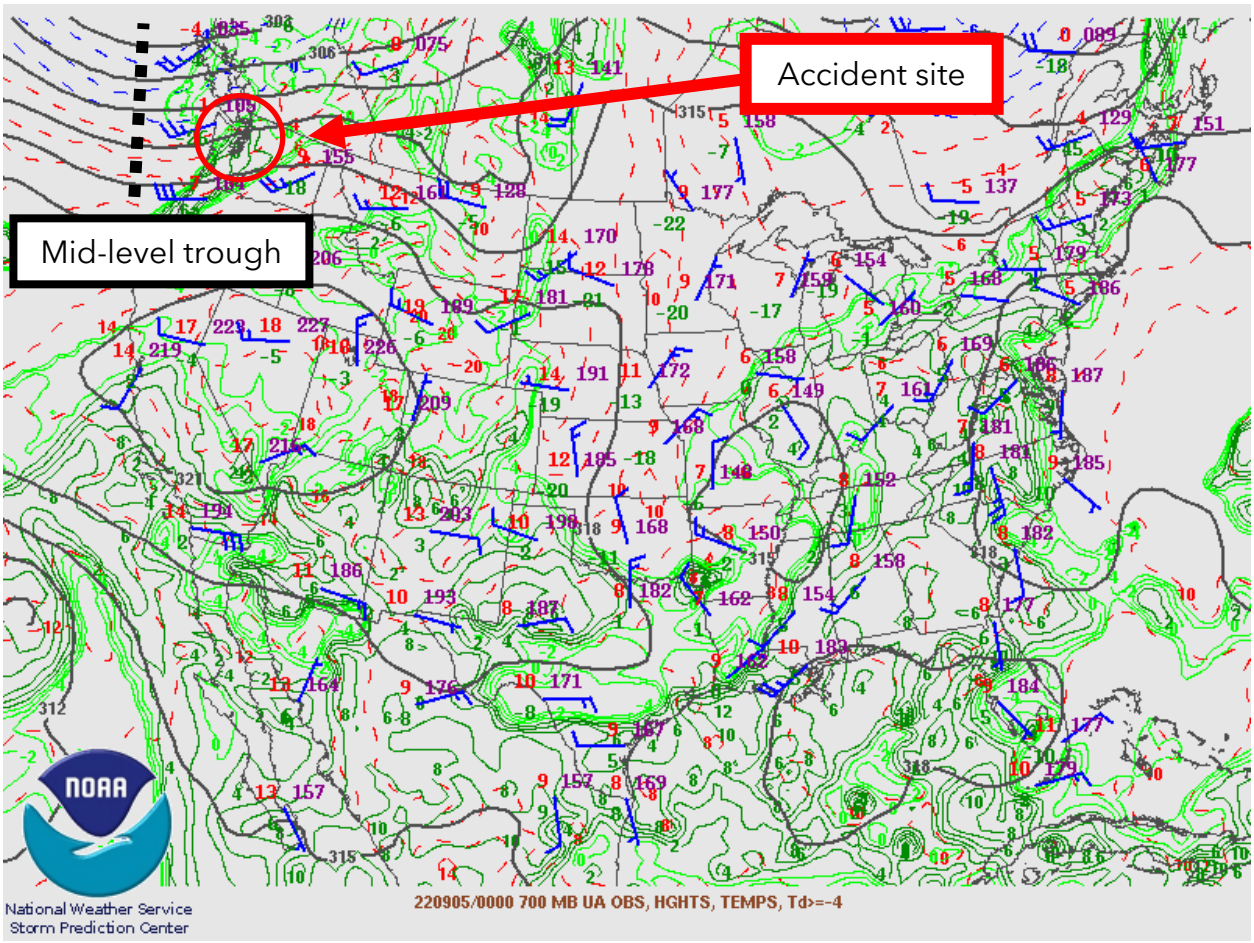

Figure 3. 700-hPa Constant Pressure Chart for 1700 PDT.

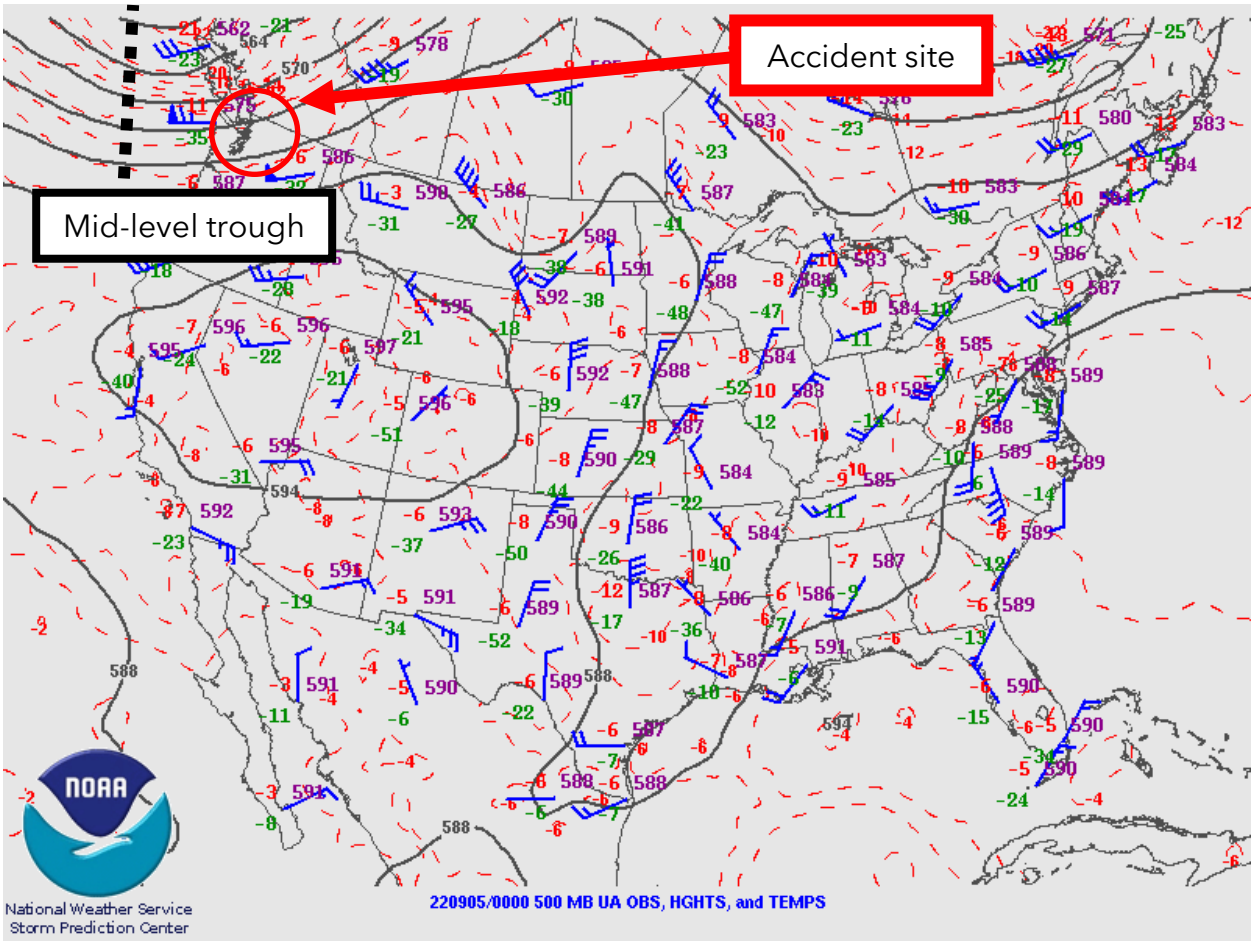

Figure 4. 500-hPa Constant Pressure Chart for 1700 PDT.

2.0 Surface Observations

The area surrounding the accident site was documented using official Aviation Routine Weather Reports (METARs) and Special Reports (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 5 is a local sectional chart with the accident site and the closest weather reporting locations marked. The chart depicted the magnetic variation[3] of 16° east over the area.

[3] Magnetic variation – The angle (at a particular location) between magnetic north and true north. Latest measurement taken from https://skyvector.com/

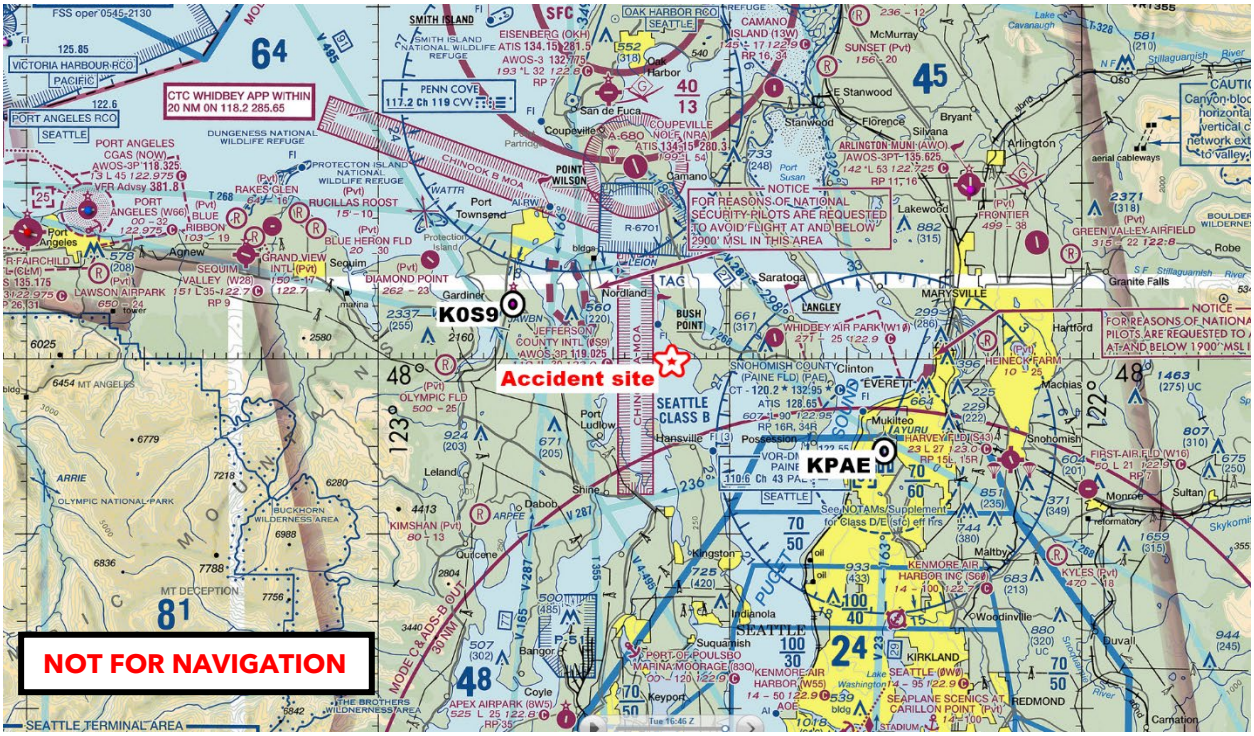

Figure 5. FAA sectional aeronautical chart of the accident area with the location of the accident site and surface observation sites.

Jefferson County International Airport (K0S9), Port Townsend, Washington, had the closest official weather station to the accident site. K0S9 had an Automated Weather Observing System (AWOS[4]) and longline[5] reports were not augmented. The K0S9 AWOS was located 10 miles west-northwest of the accident site, at an elevation of 110 feet (ft), and issued the following observations surrounding the period of the accident:[6]

> [1335 PDT] METAR K0S9 042035Z AUTO VRB04KT 10SM BKN035 BKN090 24/15 A2999 RMK AO2

[4] AWOS – Automated Weather Observing System is equipped with meteorological instruments to typically observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to 12,000 feet, and altimeter setting. AWOS are maintained by the FAA. Certain AWOS may have different reporting or observational equipment.

[5] "Longline" refers to the dissemination of weather observations with the intent that they are available in near-real time to national databases and accessible to the general global public from a large number of vendors. This does not include public accessibility to observations from a reporting station's Very High Frequency (VHF; line-of-site) or telephone broadcast, where applicable. Longline dissemination of weather observations is the primary vehicle through which the weather observations are distributed.

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

[1355 PDT] METAR K0S9 042055Z AUTO 30008KT 10SM BKN036 OVC085 23/14 A2999 RMK AO2

[1415 PDT] METAR K0S9 042115Z AUTO 32008KT 290V360 10SM FEW038 BKN085 BKN110 22/14 A3001 RMK AO2

[1435 PDT] METAR K0S9 042135Z AUTO 31008KT 10SM SCT038 BKN095 21/14 A3001 RMK AO2

[1455 PDT] METAR K0S9 042155Z AUTO 31009KT 10SM FEW038 BKN090 20/14 A3001 RMK AO2

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[1515 PDT] METAR K0S9 042215Z AUTO 31010KT 10SM FEW040 FEW075 BKN090 20/14 A3002 RMK AO2

[1535 PDT] METAR K0S9 042235Z AUTO 30008KT 10SM BKN038 BKN075 OVC095 20/14 A3002 RMK AO2

[1555 PDT] METAR K0S9 042255Z AUTO 32011KT 10SM OVC036 19/14 A3003 RMK AO2

[1615 PDT] METAR K0S9 042315Z AUTO 31012G18KT 10SM OVC036 18/15 A3003 RMK AO2

The bold type observations decoded in plain language were as follows:

K0S9 weather at 1455 PDT, automated, wind from 310° at 9 knots, visibility 10 miles or greater, few clouds at 3,800 ft above ground level (agl), broken ceiling at 9,000 ft agl, temperature of 20° Celsius (C), dew point temperature 14°C, and an altimeter setting of 30.01 inches of mercury (inHg). Remarks, automated station with a precipitation discriminator.

K0S9 weather at 1515 PDT, automated, wind from 310° at 10 knots, visibility 10 miles or greater, few clouds at 4,000 ft agl, few clouds at 7,500 ft agl, broken ceiling at 9,000 ft agl, temperature of 20°C, dew point temperature 14°C, and an altimeter setting of 30.02 inHg. Remarks, automated station with a precipitation discriminator.

Snohomish County Airport (KPAE, Paine Field), Everett, Washington, had next the closest official weather station to the accident site. KPAE had an Automated Surface Observing System (ASOS[7]) and longline reports were augmented by air traffic control (ATC) when the tower was in operation[8]. The KPAE ASOS was located 13 miles southeast of the accident site, at an elevation of 607 ft, and issued the following observations surrounding the period of the accident:

[1053 PDT] METAR KPAE 041753Z 17013G19KT 10SM OVC120 21/13 A3006 RMK AO2 SLP176 T02060128 10211 20150 58002

[1153 PDT] METAR KPAE 041853Z 17012G19KT 10SM OVC095 21/13 A3005 RMK AO2 SLP173 T02060128

[1253 PDT] METAR KPAE 041953Z 17017G24KT 10SM OVC085 22/11 A3004 RMK AO2 SLP171 T02170111

[1353 PDT] METAR KPAE 042053Z 17015G25KT 10SM OVC090 23/11 A3003 RMK AO2 PK WND 15030/2017 SLP167 T02280111 57008

[1453 PDT] METAR KPAE 042153Z 20012G23KT 10SM OVC070 23/12 A3003 RMK AO2 PK WND 18028/2128 SLP167 T02280117

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[1553 PDT] METAR KPAE 042253Z 20010KT 10SM OVC060 23/13 A3004 RMK AO2 SLP171 T02280128

[1653 PDT] METAR KPAE 042353Z VRB04KT 10SM SCT036 OVC060 21/14 A3005 RMK AO2 RAB15E50 SLP175 P0000 60000 T02060139 10228 20206 53006

[1753 PDT] METAR KPAE 050053Z 10SM SCT028 OVC037 17/13 A3006 RMK AO2 SLP179 T01720133

The bold type observations decoded in plain language were as follows:

[7] ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, weather phenomena, ceiling, temperature, dewpoint, altimeter, and barometric pressure. ASOS are maintained by the NWS.
[8] ATC hours of operation 0700 to 2100 local.

KPAE weather at 1453 PDT, wind from 200° at 12 knots with gusts to 23 knots, visibility 10 miles or greater, overcast ceiling at 7,000 ft agl, temperature of 23°C, dew point temperature 12°C, and an altimeter setting of 30.03 inHg. Remarks, automated station with a precipitation discriminator, peak wind from 180° at 28 knots at 1428 PDT, sea level pressure 1016.7 hPa, temperature 22.8°C, dew point temperature 11.7°C.

KPAE weather at 1553 PDT, wind from 200° at 10 knots, visibility 10 miles or greater, overcast ceiling at 6,000 ft agl, temperature of 23°C, dew point temperature 13°C, and an altimeter setting of 30.04 inHg. Remarks, automated station with a precipitation discriminator, sea level pressure 1017.1 hPa, temperature 22.8°C, dew point temperature 12.8°C.

The observations from K0S9 and KPAE surrounding the accident time indicated VFR[9] conditions prevailed with a northwest wind at K0S9 and a southwesterly wind at KPAE.

Several unofficial surface observations sites were found close to the accident site and locations are documented in figure 6 using the MesoWest network[10]. FW3783 Clinton (F3783)[11] and CW5456 Hansville (C5456)[12] stations were located within 4 miles from the accident site. The data from FW3783 and C5456 indicated that the wind shifted from the southeast to northwest around the accident time and additional data can be found in attachments 1 and 2[13].

[9] As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- Low Instrument Flight Rules (LIFR*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

[10] MesoWest Data (utah.edu)

[11] MESOWEST STATION INTERFACE (utah.edu)

[12] MESOWEST STATION INTERFACE (utah.edu)

[13] Maintenance schedule and reliability for these stations is unknown.

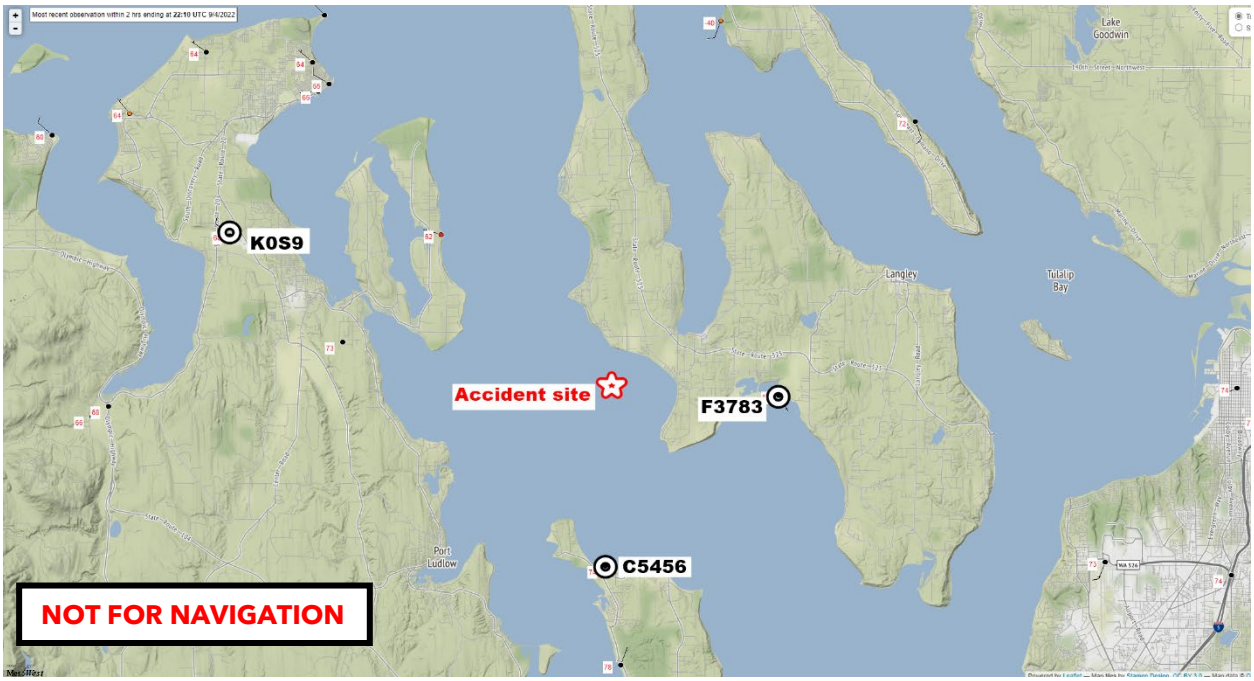

Figure 6. Accident site map with additional surface observation sites.

3.0 Upper Air Sounding

A High-Resolution Rapid Refresh (HRRR)[14] model sounding was created for the approximate accident site coordinates for 1500 PDT (figure 7). The 1500 PDT HRRR sounding was plotted on a standard Skew-T Log P diagram[15] using the RAOB software[16] from the surface to 600-hPa (or approximately 14,000 ft) along with the derived stability parameters and is included as figure 7. The sounding depicted the lifted condensation level (LCL)[17] at 2,792 ft and the convective condensation level (CCL)[18] at 4,063 ft. The freezing level was located at 12,265 ft with the precipitable water value at 1.37 inches.

[14] 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.
[15] 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.
[16] RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Eosonde Research Services, The Villages, Florida.
[17] LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.
[18] 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.

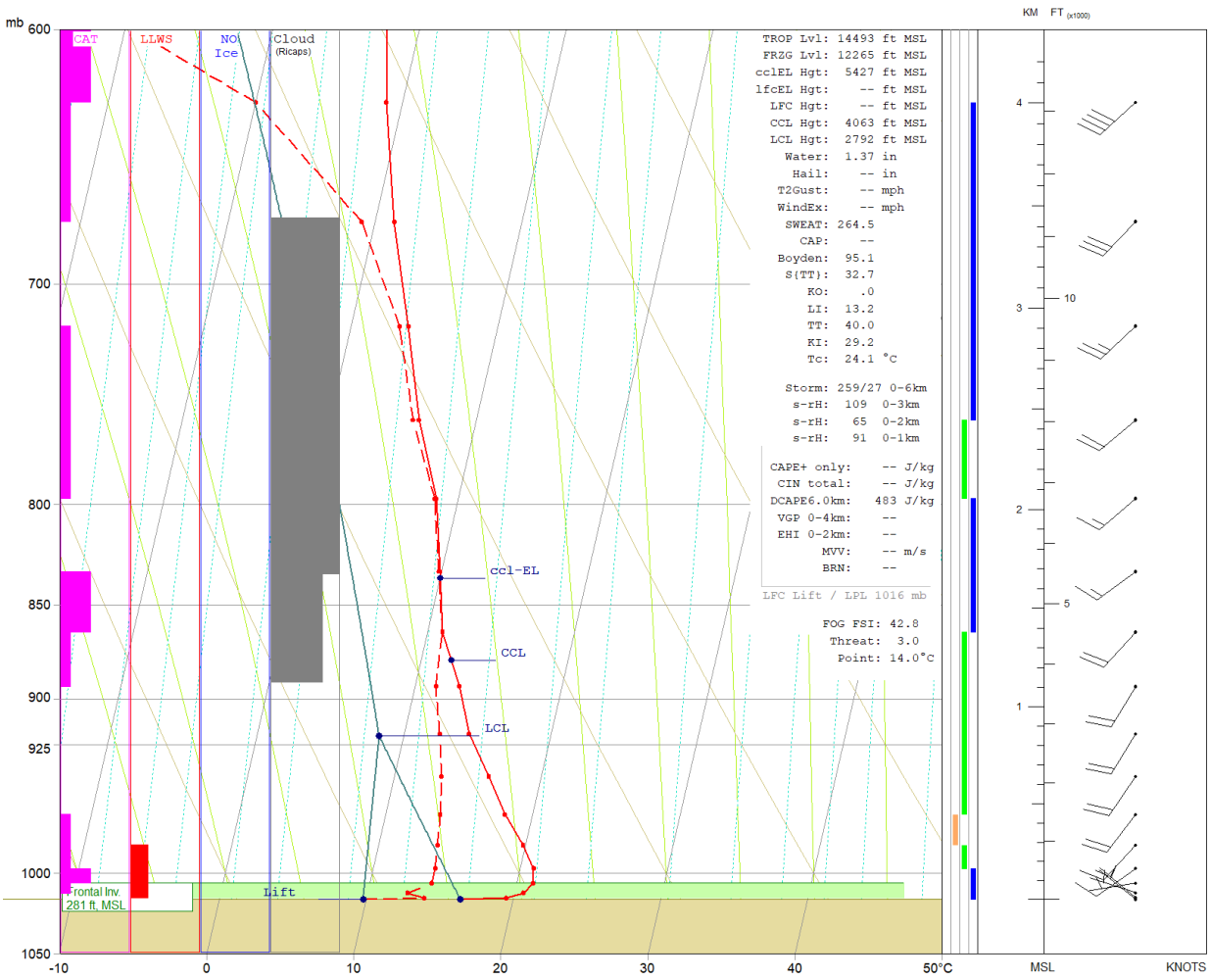

Figure 7. 1500 PDT HRRR sounding.

The 1500 PDT HRRR sounding indicated a stable environment from the surface through 500 ft agl, with a conditional unstable layer between 500 ft agl and 4,500 ft. Clouds were indicated by RAOB to be present from 3,700 ft through 11,500 ft. The top of a frontal inversion[19] was noted at 281 ft. No icing potential was indicated by RAOB below 14,000 ft.

[19] Inversion – A departure from the usual decrease of the value of an atmospheric property with increasing altitude; also, the layer through which this departure occurs (the "inversion layer"), or the lowest altitude at which the departure is found (the "base of the inversion").

The 1500 PDT HRRR sounding wind profile indicated a near surface wind from 311° at 3 knots with the wind becoming southwesterly by 500 ft. The wind speed increased to 10 knots by 1,000 ft and 20 knots by 1,500 ft. The RAOB analysis program indicated the possibility of moderate low-level wind shear (LLWS) below 700 ft with several layers of light to moderate clear air turbulence (CAT) from the surface through 14,000 ft. At the accident flight's elevation before descent[20] of around 1,000 ft, the temperature was 19.8°C , the dew point temperature was 14.0°C, the wind was from 221° at 16 knots, with a relative humidity of 69%.

4.0 Satellite Data

The Geostationary Operational Environmental Satellite number 17 (GOES-17) visible and infrared data were 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-17 bands 2 and 13) at wavelengths of 0.64 microns (μm) and 10.3 μm, respectively, were retrieved for the period from 1100 PDT through 2000 PDT and reviewed, and the closest images to the time of the accident were documented.

Figure 8 presents the GOES-17 visible imagery from 1511 PDT at 2X magnification with the accident site highlighted with a red square and cloud cover indicated above the accident site. The cloud cover was moving from southwest to northeast through the accident time (attachment 3). Figure 9 presents the GOES-17 infrared image at 1511 PDT at 6X magnification with the accident site highlighted with a red square. The image depicted cloud cover over the accident site. The lower brightness temperatures (green and yellow colors; higher cloud tops) were located north, east, and west of the accident site at the accident time. The brightness temperature of 274 Kelvin above the accident site would have been near 11,000 ft based on the vertical temperature profile provided by the 1500 PDT HRRR sounding. It should be noted these figures have not been corrected for any parallax error.

[20] See docket for more track information and data.

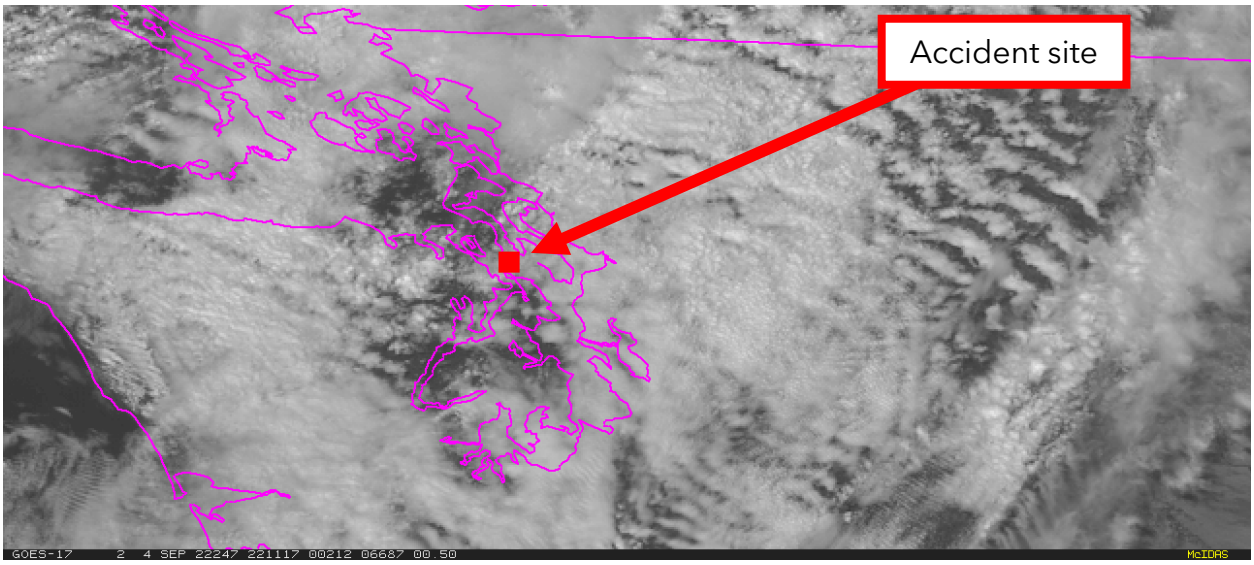

Figure 8. GOES-17 visible image at 1511 PDT.

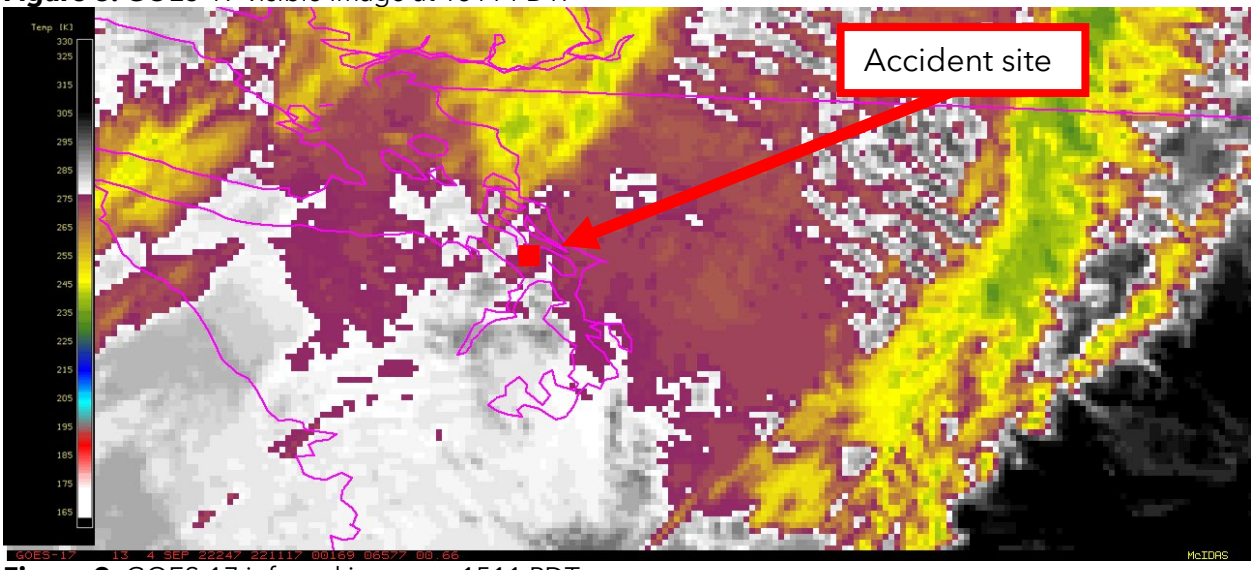

Figure 9. GOES-17 infrared image at 1511 PDT.

5.0 National Radar Imagery

A regional view of the NWS National Reflectivity Mosaic is included as figure 10 for 1510 PDT with the approximate location of the accident site marked by a red circle. The image depicted no precipitation echoes above the accident site.

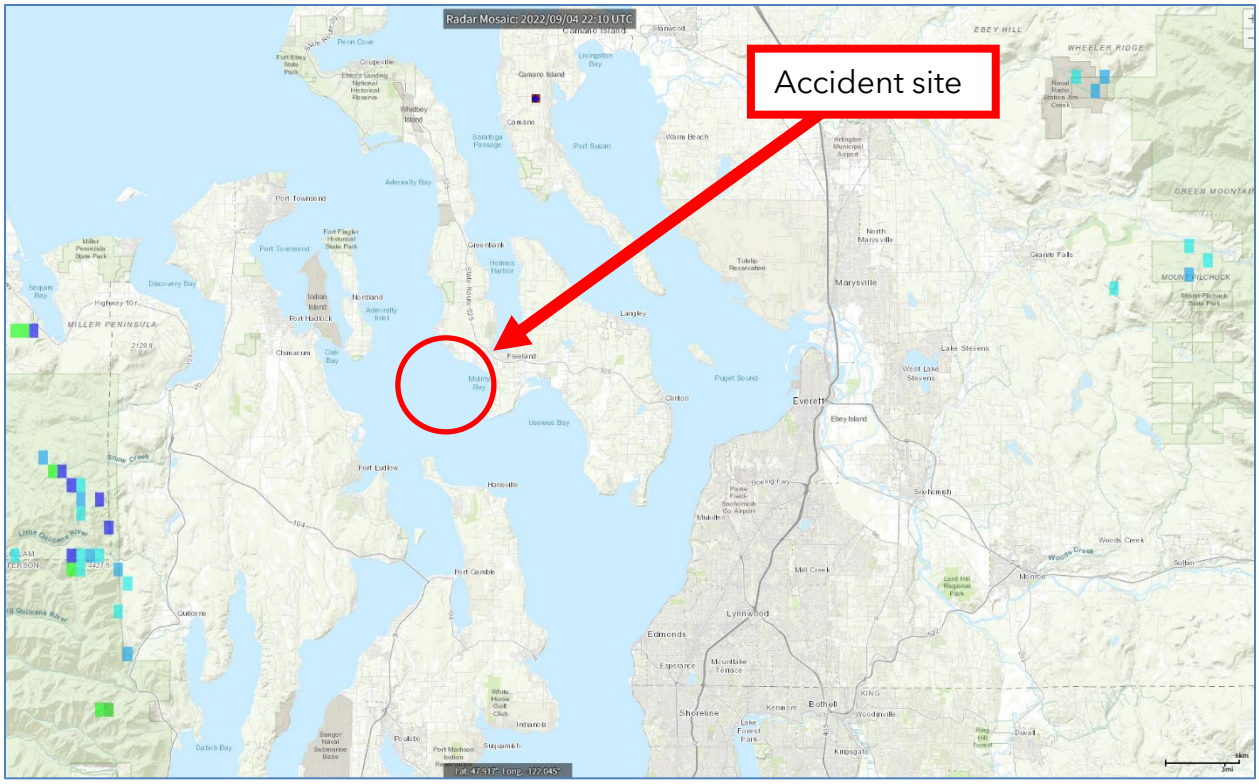

Figure 10. National Reflectivity Mosaic for 1510 PDT.

6.0 Weather Surveillance Radar Imagery

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[21] to the accident site was Camano Island, Washington, WSR-88D, (KATX) located 13 miles northwest of the accident site. The 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.

6.1 Volume Scan Strategy

During the period surrounding the accident, the KATX WSR-88D radar was operating in the clear-air mode VCP-35[22] (figure 11). The following figure 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.

[21] 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.
[22] Volume Coverage Pattern (VCP)-212.

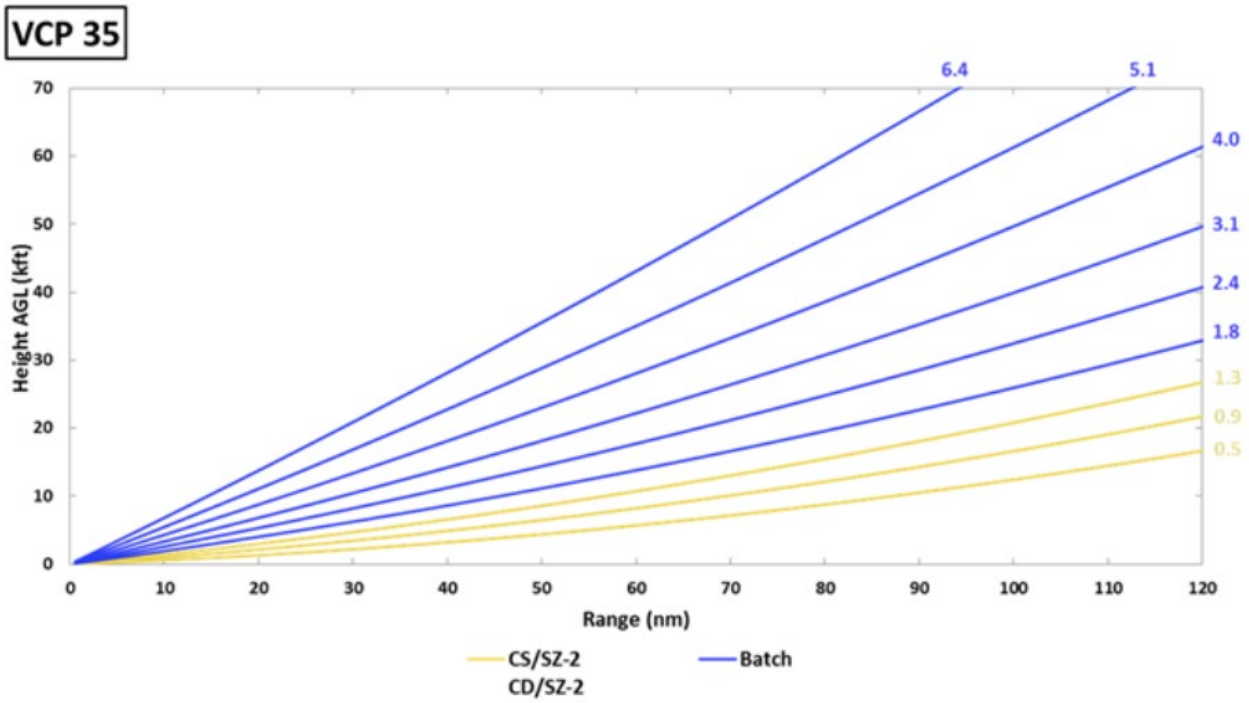

Figure 11. VCP-35 Clear-air Mode Scan Strategy[23].

6.2 Beam Height Calculation

Assuming standard refraction[24] of the KATX WSR-88D radar beam with the antenna elevation at 642 ft, and considering a beamwidth[25] of 0.95°, the following table shows the approximate heights for the radar beam center, top and base for antenna elevations over the accident site. These heights have been rounded to the nearest 10 ft.

[23] 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)

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

[25] Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
KATX 0.5°	1,490 ft	830 ft	2,150 ft

Based on the radar height calculations, the elevation scans reviewed from KATX listed in the above table depicted the conditions between 830 ft and 2,150 ft over the accident site.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[26] 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 dBZ[27] and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C[28], "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 to 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as "extreme."

[26] 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.

[27] 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.

[28] https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020774

6.4 Base Reflectivity and Lightning Data

Figure 12 presents the KATX WSR-88D base reflectivity image for the 0.5° elevation scan initiated at 1508:01 PDT with a resolution of 0.5° X 250 m. The flight track data[29] of N725TH has been overlaid in pink for context. The image depicted reflectivity values between -5 and 5 dBZ over the accident site at the time of the accident. An animation of the echoes revealed that the area of low dBZ values were moving from northwest to southeast and corresponded to the timing of the wind shifts documented at FW3783 and C5456 (attachment 4). The area of low dBZ values moving across the accident site at the accident time had Correlation Coefficient[30] (CC) values at or below 0.8 (attachment 5).

There were no lightning flashes[31] within 30 miles of the accident site 30 minutes either side of the accident time.[32]

[29] For more information please see the docket in this accident.
[30] CC is a measure of how similar the horizontal and vertical returned pulse characteristics are among all pulses in the sampled WSR-88D volume. CC provides information about the diversity of hydrometeors within the volume and the values range from 0 to 1. Meteorological echoes tend to have CC values greater than 0.80, with values greater than 0.96 indicating that the meteorological targets within the volume are all very similar in size, shape, type (liquid versus solid), and orientation. CC values between 0.96 and 0.80 indicate that the meteorological targets within the volume have a higher diversity of sizes, shapes, types, and orientations as the CC trends lower. If hail is located within the volume scanned the CC values are typically between 0.80 and 0.96. Non-meteorological echoes have CC values less than 0.80 and these non-meteorological echoes can include, but are not limited to, bugs, chaff, smoke and birds. Definition for CC adapted from training material from the NWS WDTD.
[31] Lightning Flash – This is one contiguous conducting channel and all the current strokes/pulses that flow through it. There are two types of flashes: ground flashes and cloud flashes.
[32] A review of Earth Networks Total Lightning network and GOES-17 Geostationary Lightning Mapper was done.

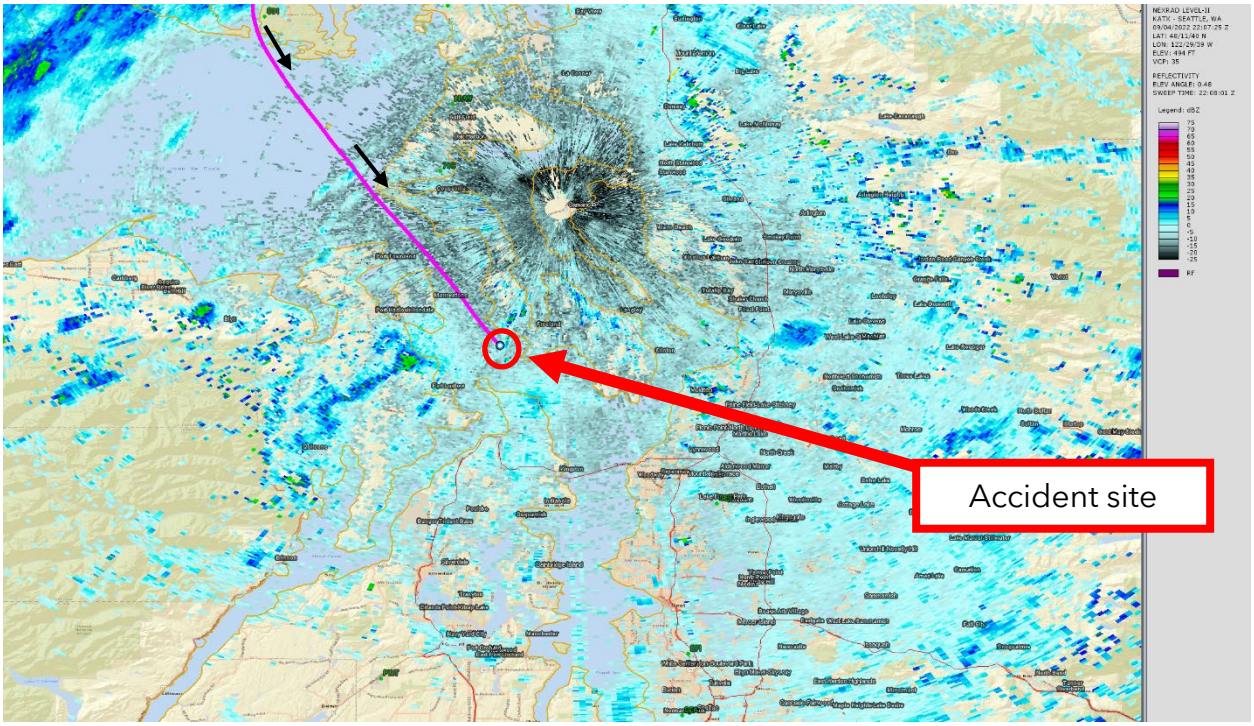

Figure 12. KATX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1508:01 PDT with the accident site marked with the red circle. The flight track is in pink with arrows pointing in the direction of travel.

7.0 Pilot Reports

The longline-disseminated pilot reports[33] (PIREPs) distributed into the national airspace system (NAS) were reviewed for about two hours on either side of the accident time and the PIREPs issued into the NAS within 100 miles of the accident site for below 19,000 ft are shown below:

TIW UA /OV KTIW/TM 2010/FL045/TP C172/TB NEG

RNT UA /OV KRNT/TM 2016/FL045/TP C172/TB MOD

CLS UA /OV KCLS/TM 2040/FL035/TP C172/TB LGT

OLM UA /OV KOLM/TM 2109/FL030/TP C172/TB NEG

PAE UA /OV S60/TM 2121/FL025/TP DH3T/TB LGT

CLM UA /OV KCLM/TM 2339/FL001/TP C172/RM NEG RA

An additional PIREP was provided by a flight going from north to south near Whidbey Island around 1430 PDT and that information is contained in attachment 8.

[33] Only pilot reports with the World Meteorological Organization headers UBWA** and UBOR** were considered. These do not include pilot reports only broadcast via radio.

8.0 Significant Meteorological Information

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

9.0 Center Weather Service Advisories

The Seattle (ZSE) Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU) was responsible for the accident region. There was no Center Weather Advisory (CWA) valid from ZSE CWSU at the accident time.

10.0 Airmen's Meteorological Information

The NWS Aviation Weather Center had Airmen's Meteorological Information (AIRMET) advisories Sierra and Tango were valid for the accident site at the accident time. The text AIRMETs Sierra and Tango were issued at 1345 PDT and forecast mountain obscuration conditions due to clouds and mist and moderate turbulence below 12,000 ft:

WAUS46 KKCI 042045
WA6S
-SFOS WA 042045
AIRMET SIERRA UPDT 4 FOR IFR AND MTN OBSCN VALID UNTIL 050300
.
AIRMET IFR...WA OR CA AND CSTL WTRS
FROM 40NNW TOU TO 50SW HUH TO 20WSW EUG TO 70W OED TO 60SW OED
TO 20E FOT TO 150SW PYE TO 140WSW FOT TO 140WSW ONP TO 40W HQM
TO 60WNW TOU TO 40NNW TOU
CIG BLW 010/VIS BLW 3SM BR/FG. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET MTN OBSCN...WA OR
FROM 20SSE YDC TO 40ESE SEA TO 30NNE BTG TO 30ESE ONP TO 70NNW
FOT TO 40NNW ONP TO 40SSW HQM TO 20WNW HQM TO 20NNW TOU TO
20WNW HUH TO 20SSE YDC
MTNS OBSC BY CLDS/BR. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET MTN OBSCN...WA OR CA ID MT WY NV
FROM 90WSW YXC TO 60WNW HVR TO 20NE GTF TO 50ENE LWT TO 20N CZI
TO 40NNW BOY TO 80SW BIL TO 40NE DBS TO 50S TWF TO 20NW REO TO
20W RBL TO 20NNE FOT TO 30W DSD TO 60S GEG TO 90WSW YXC
MTNS OBSC BY FU/HZ. CONDS CONTG BYD 03Z THRU 09Z.
....

WAUS46 KKCI 042045
WA6T
-SFOT WA 042045
AIRMET TANGO UPDT 3 FOR TURB AND STG SFC WNDS VALID UNTIL 050300

.
AIRMET TURB...WA OR AND CSTL WTRS
FROM 90WSW YXC TO 40ENE BTG TO 20NNW ONP TO 100W ONP TO 140W TOU
TO 20NNW TOU TO HUH TO 90WSW YXC
MOD TURB BTN FL230 AND FL430. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET TURB...WA OR AND CSTL WTRS
FROM 90WSW YXC TO 20WSW PDT TO 50ESE BTG TO 30SSE HQM TO 20WNW
HQM TO 30WNW TOU TO HUH TO 30S YDC TO 90WSW YXC
MOD TURB BLW 120. CONDS CONTG BYD 03Z THRU 09Z.
•
AIRMET STG SFC WNDS...CA AND CSTL WTRS
FROM 40WNW FOT TO 60SSE FOT TO 90SW PYE TO 90WSW ENI TO 40WNW FOT
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 21-00Z.
CONDS CONTG BYD 03Z ENDG 06-09Z.
.
OTLK VALID 0300-0900Z...TURB WA OR ID MT AND CSTL WTRS
BOUNDED BY 20W HUH-90ESE YDC-60WNW HVR-20SW GTF-30SSE FCA-50S
EPH-40N DSD-100W ONP-140W TOU-20W HUH
MOD TURB BTN FL230 AND FL430. CONDS CONTG THRU 09Z.
....

11.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products issued before the accident flight and valid at 1400 and 1700 PDT are shown in attachment 6. The GFA surface forecast applicable to the accident site that was valid before the accident flight's departure for times surrounding the accident time indicated VFR surface visibilities, a chance (between 30 and 60 percent) of rain, and a southwest wind of 10 knots at 1400 PDT becoming a northwest surface wind at 10 knots by 1700 PDT. The GFA cloud forecast applicable to the accident site that was valid before departure for times surrounding the accident time indicated broken to overcast cloud coverage with no forecast point located close to the accident site. The Graphical AIRMET[34] (G-AIRMET) Sierra valid for the accident site at the accident time is located on the GFA cloud forecast graphic. The only human-generated information reflected in the two GFA products were the G-AIRMETs.

[34] **Graphical AIRMETs (G-AIRMETs)**, found on the Aviation Weather Center webpage at http://aviationweather.gov, are graphical forecasts of en-route weather hazards valid at discrete times no more than 3 hours apart for a period of up to 12 hours into the future (for example, 00, 03, 06, 09, and 12 hours). G-AIRMETs are snap shots at discrete time intervals as defined above. The text AIRMET is the result of the production of the G-AIRMET but provided in a time smear for a 6hr valid period.

12.0 Terminal Aerodrome Forecast

KPAE was the closest site with an NWS Terminal Aerodrome Forecast[35] (TAF) current at the time of the accident. The KPAE TAF valid before departure was issued at 1040 PDT and was valid for a 24-hour period beginning at 1100 PDT. The 1040 PDT TAF for KPAE was as follows:

FTUS46 KSEW 041740
TAFPAE
TAF
KPAE 041740Z 0418/0518 16012KT P6SM SCT040 BKN120
FM042000 27007KT P6SM VCSH BKN040 OVC090
FM042300 30007KT P6SM VCSH SCT020 BKN050
FM050500 VRB03KT P6SM BKN025
FM051400 34003KT P6SM OVC015=

Between 1300 and 1600 PDT the forecast expected a wind from 270° at 7 knots, greater than 6 miles visibility, vicinity[36] showers, a broken ceiling at 4,000 ft agl, and overcast skies at 9,000 ft agl.

13.0 National Weather Service Area Forecast Discussion

The NWS weather forecast office in Seattle, Washington, (WFO SEW) was responsible for the public forecast in the region of the accident site. WFO SEW issued the following Area Forecast Discussion (AFD) at 1050 PDT, the closest AFD to the accident time with an aviation section:

FXUS66 KSEW 041750
AFDSEW

Area Forecast Discussion
National Weather Service Seattle WA
1050 AM PDT Sun Sep 4 2022

.UPDATE...A weak front is offshore this morning bringing light rain to the coast. The front will bring increasing clouds across the interior late morning through the afternoon. The best potential for light rain showers for the interior will be this afternoon/evening. Clouds into tonight, drier Monday with a ridge building.

[35] According to NWS Instruction 10-813: "An NWS TAF consists of the expected meteorological conditions significant to aviation at an airport for a specified time period. For the U.S., this is the area within five (5) statute miles (SM) of the center of an airport's runway complex." www.nws.noaa.gov/directives/sym/pd01008013curr.pdf

[36] In the vicinity of the airport is defined as a weather phenomenon within 5-10 statute miles of the airfield.

&&

.SYNOPSIS...A weakening front will bring a little light rain
through this evening to the area. An upper ridge will build into
the area for drier, warmer weather Monday through Wednesday. An
upper trough will bring cooler weather Thursday, with a building
ridge late week.

&&

.SHORT TERM /TODAY THROUGH TUESDAY/...A weakening front will
bring a little rain later today with the best chances over the
north coast. The interior from about Seattle south will be mostly
sunny with clouds increasing in the afternoon and a chance of rain
late. Highs will be close to normal. There will be plenty of
lingering clouds on Monday in the wake of the front but the sun
should come out in the afternoon as an upper ridge starts to
build over the area. Highs will be slightly cooler on Monday. The
upper ridge will continue to build on Tuesday with highs warming
to a few degrees above normal and plenty of sunshine. 16

.LONG TERM /WEDNESDAY THROUGH SATURDAY/...An upper ridge over the
area will shift inland on Wednesday but it should be a mostly
sunny and warm day for most of the area with highs about 5 degrees
above normal. An upper trough will brush the area Wednesday night
and Thursday. Ensembles show most of the associated
precipitation passing to the north so the main impact will be to
bring more clouds and cool highs back to near normal on Thursday.
An upper ridge will rebuild over the area Friday and Saturday but
low level onshore flow should keep temperatures seasonable. 16

&&

**.AVIATION...A weakening front is pushing into the coast today,
with increasing mid-level clouds bringing lower VFR to MVFR ceilings
onshore and pockets of IFR conditions in rain closer to the coast.
Expect these trends to continue as the front pushes onshore and
breaks apart through the day as it pushes into the Cascades. Gusty
southerly winds ahead of the front will increase, with a shift to
west/southwest surface winds behind the front. Gradient becomes
north/northwest late tonight/early Monday, with gradually clearing
skies. Mountains likely obscured in the clouds and rain later
morning through the remainder of the day.**

KSEA...Increasing mid-level clouds with gradually lowering ceilings
through day as front approaches. Expect mostly VFR ceilings through
the day with only few light rain showers around the area. Lowering
ceilings overnight with residual moisture and increasing stability
likely to bring MVFR ceilings overnight through early Monday.

&&

.MARINE...A weakening front pushes onshore today, with increasing

southerly winds ahead of the front. Advisory for the coastal waters will end later today as winds shift behind the front and ease. A west push through the Strait of Juan de Fuca likely follows, with winds to 25 kt in the central Strait of Juan de Fuca this evening, perhaps also extending through into the east entrance of the Strait. Seas generally around 3 to 5 ft over the coastal waters through early next week, generally dominated by a shorter period component. High pressure rebuilds Monday and Tuesday. Another system likely arrives late Wednesday for another round of stronger winds and potential for additional headlines at that time. Cullen

&&

FIRE WEATHER...An upper ridge will bring dry and warmer weather Tuesday and Wednesday. Mid level haines of 6 are expected at times over the Cascades. For now, it looks like minimum relative humidities will not be low enough to meet critical fire weather thresholds but it will be close and will need to be monitored. An upper trough will bring cooler weather with higher humidities late in the week for improving fire weather conditions. 16

&&

.HYDROLOGY...The daily hydrology discussion has ended until the start of the next rainy season; it will only be updated as needed.

&&

.SEW WATCHES/WARNINGS/ADVISORIES...
WA...None.
PZ...Small Craft Advisory from 4 PM this afternoon to 11 PM PDT this evening for Central U.S. Waters Strait Of Juan De Fuca.

Small Craft Advisory until 2 PM PDT this afternoon for Coastal Waters From Cape Flattery To James Island 10 To 60 Nm-Coastal Waters From Cape Flattery To James Island Out 10 Nm-Coastal Waters From James Island To Point Grenville 10 To 60 Nm-Coastal Waters From James Island To Point Grenville Out 10 Nm-Coastal Waters From Point Grenville To Cape Shoalwater 10 To 60 Nm-Coastal Waters From Point Grenville To Cape Shoalwater Out 10 Nm.

&&

$$

14.0 Winds and Temperature Aloft Forecast

The NWS 1259 PDT Winds and Temperature Aloft forecast valid for the closest point to the accident site is included below:

FBUS31 KWNO 041959
FD1US1
DATA BASED ON 041800Z
VALID 050000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000
SEA 2313 2217+10 2325+05 2338+01 2357-09 2371-21 239837 730446 249852

The closest forecast point to the accident site was Seattle, Washington, (SEA). The 1259 PDT SEA forecast for use between 1300 PDT and 2000 PDT indicated a wind from 230° at 13 knots at 3,000 ft, a wind at 6,000 ft from 220° at 17 knots with a temperature of +10°C, and a wind at 9,000 ft from 230° at 25 knots with a temperature of +5°C.

15.0 Witness Information

Video imagery was provided by ShunkBayWeather.com showing the cloud cover movement and wind patterns surrounding the accident time (attachment 7). The location and direction of cameras can be found in figure 13.

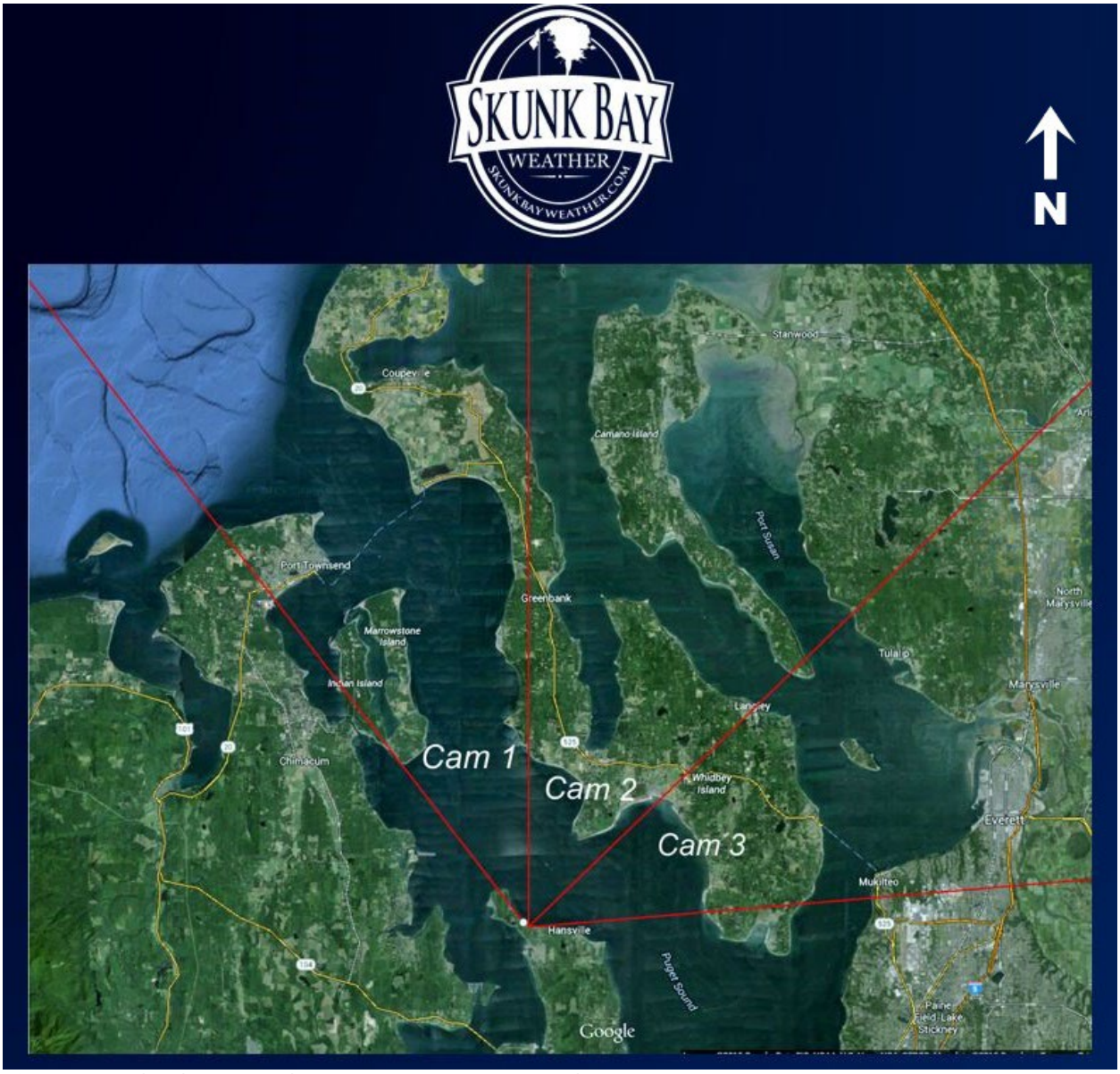

Figure 13. SkunkBayWeather.com camera imagery directions.

16.0 Pilot Weather Information

Title 14 CFR 91.103 states that "Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight." FAA AC 91-92 "Pilot's Guide to a Preflight Planning" (dated March 15, 2021) provided pilot guidance on preflight self-briefings, including planning, weather interpretation, and risk identification/mitigation skills. The AC further stated in part:

Pilots adopting these guidelines will be better prepared to interpret and utilize real-time weather information before departure and en route, in the cockpit, via technology like Automatic Dependent Surveillance-Broadcast (ADS-B) and via third-party providers. [37]

A search of archived information indicated that the accident pilot did not request weather information from Leidos Flight Service or ForeFlight. The accident pilot did use their ForeFlight account to update a route string on the day of the accident, but no airport information or weather imagery was viewed inside the ForeFlight App (attachment 9). For more information regarding the accident pilot and weather information and knowledge please see the Operational Factors Factual contained in the docket for this investigation.

17.0 Astronomical Data

The astronomical data obtained for the accident site on September 4, 2022, indicated the following:

SUN	
Begin civil twilight	0601 PDT
Sunrise	0632 PDT
Sun transit	1309 PDT
Accident time	**1509 PDT**[38]
Sunset	1945 PDT
End civil twilight	2017 PDT

At the time of the accident the Sun was located at an altitude of 41.72° and azimuth of 221.58°.

[37] https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-92.pdf. The AC also listed multiple online FAA resources for aviation flight planning services for adverse weather.
[38] Inserted accident time for reference and context.

E. LIST OF ATTACHMENTS

Attachment 1 – Observations from F3783 surrounding the accident time

Attachment 2 – Observations from C5456 surrounding the accident time

Attachment 3 – GOES-17 visible satellite animation from 1431 to 1531 PDT

Attachment 4 – KATX base reflectivity animation of the 0.5° elevation scan from 1417 to 1525 PDT

Attachment 5 – KATX CC animation of the 0.5° elevation scan from 1417 to 1525 PDT

Attachment 6 – GFA information valid at the accident time

Attachment 7 – Video imagery from around the accident time

Attachment 8 – Additional PIREP

Attachment 9 – ForeFlight Information

Submitted by:

Paul Suffern
Senior Meteorologist