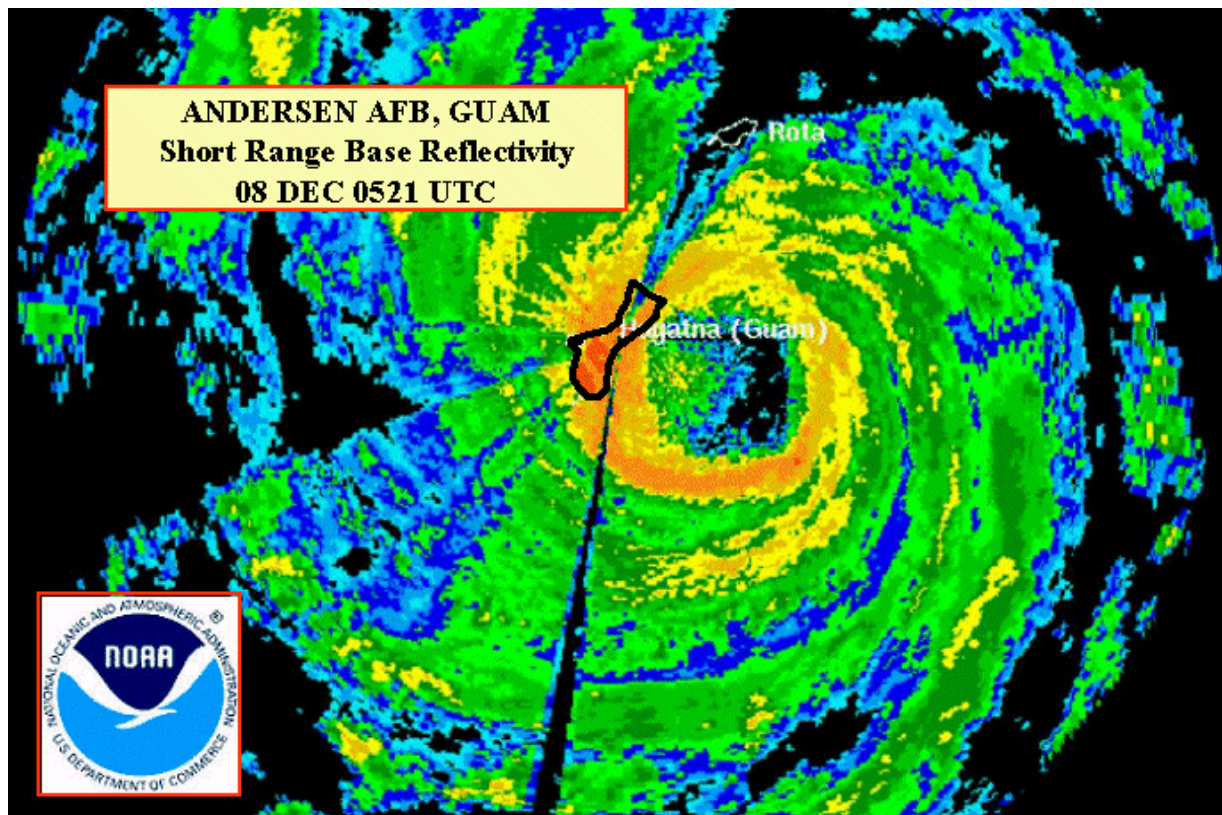




## *Service Assessment*

# Super Typhoon Pongsona December 8, 2002



**U.S. DEPARTMENT OF COMMERCE**  
**National Oceanic and Atmospheric Administration**  
National Weather Service  
Silver Spring, Maryland

**Cover:** Radar image of Pongsona, showing the wall cloud surrounding the eye, as it began to move over Guam at 3:21 p.m., Sunday, December 8, 2002.



## *Service Assessment*

# **Super Typhoon Pongsona December 8, 2002**

**April 2003**

**U.S. DEPARTMENT OF COMMERCE**

**Donald L. Evans, Secretary**

**National Oceanic and Atmospheric Administration**

Vice Admiral Conrad C. Lautenbacher, Jr., Administrator

National Weather Service

John J. Kelly, Jr., Assistant Administrator

# Preface

Super Typhoon Pongsona (Pong-sahn-WAH) was one of the most intense typhoons to ever strike the island of Guam. It was comparable to Super Typhoon Paka (1997) and was exceeded only by Karen (1962) and the Typhoon of 1900.

Due to the magnitude of this event and its impact on Guam, a service assessment team was formed to examine the warning and forecast services provided to the Guam Civil Defense and local officials, the media, and the public. Service assessments provide a valuable contribution to ongoing efforts to improve the quality and timeliness of the National Weather Service products and services. Findings in this assessment will help to improve techniques, products, services, and the information provided to the American public.

**John J. Kelly, Jr.**  
**Assistant Administrator**  
**for Weather Services**

**April 2003**

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# Service Assessment Team

This service assessment team was activated on December 12, 2002. The Weather Forecast Office (WFO) Guam briefed the team on December 18. Team members visited the Pacific Region Headquarters; WFO Honolulu, Hawaii; the Joint Typhoon Warning Center (JTWC); and various emergency management, civil defense, government, military, and private sector agencies and organizations, as well as broadcast media outlets. In addition, telephone interviews were conducted with officials on the islands of Rota and Saipan, and individuals from several external organizations.

The team comprised the following individuals.

<b>Paul Duval</b>	<i>Team Leader</i> , Meteorologist in Charge (MIC), WFO Tallahassee, Florida
<b>Dr. John Beven</b>	Hurricane Specialist, Tropical Prediction Center, Miami, Florida
<b>Delores Clark</b>	National Oceanic and Atmospheric Administration (NOAA) Public Affairs Officer, Pacific Region Headquarters
<b>Dr. Mark Lander</b>	Professor, University of Guam
<b>Hendricus Lulofs</b>	Warning Coordination Meteorologist, WFO Caribou, Maine
<b>Dr. John Marra</b>	NOAA Coastal Natural Hazards Specialist, Perot Systems Government Services
<b>Rafael Mojica</b>	Warning Coordination Meteorologist, WFO San Juan, Puerto Rico
<b>Ken Waters</b>	Regional Scientist, Pacific Region Headquarters

Other valuable contributors:

<b>Col. Mark Weadon</b>	U.S. Air Force Deputy for Federal Programs and NOAA Office of Military Affairs
<b>William Lerner</b>	NWS Headquarters, Office of Climate, Water, and Weather Services, Silver Spring, Maryland
<b>Linda Kremkau</b>	NWS Headquarters, Office of Climate, Water, and Weather Services, Silver Spring, Maryland

The team would like to thank the following who took time to talk with team members.

### **NWS Offices**

Staff, WFO Tiyan, Guam  
Staff, WFO Honolulu, Hawaii  
Staff, NWS Pacific Region Headquarters

### **Federal Agency Personnel**

Joint Typhoon Warning Center (JTWC)  
Robert Fenton, Operations Chief, Federal Emergency Management Agency, Region IX  
Joyce P. Cruz, LT(jg), Assistant Operations Officer, U.S. Coast Guard, Marianas Section  
Captain Lorigan, Commander, U.S. Coast Guard, Marianas Section Operations  
Brian Black, LT(jg), U.S. Navy  
Bruce Best, Guam Station Administrator, PEACESAT

### **Guam and Commonwealth of Northern Mariana Islands (CNMI) Government Personnel**

Leo Espia, Earthquake Program Manager, Guam Office of Civil Defense  
Joe G. Javellana III, Administrator, Guam Office of Civil Defense  
Francisco Santos, Harbor Master, Guam Port Authority  
Mike Gawel, Director, Guam Bureau of Statistics and Plans, Guam Coastal Management Program  
Anthony M. Calvo, Federal Programs Coordinator, CNMI Emergency Management Office, Office of the Director  
John F. Blas, Executive Director of the Mayors Council on Guam  
Gerald Yingling, Director, Guam Airport Authority

### **Media**

Benny T. Flores, Operations Manager, KGTF-TV, Channel 12  
Shawn Gumataotao, News 8 Anchor/Reporter, KUAM-TV, Channel 8  
Edward Poppe, President, Inter-Island Communications Inc., KSTO Radio  
Jon Anderson, President, Sorenson Pacific Broadcasting Inc., K57 AM Radio  
Mana Silver, News Director, K57 AM Radio  
Rindraty C. Limtiaco, Managing Editor, Guam Pacific Daily News  
Lee Webber, Publisher, Guam Pacific Daily News  
David Crisostomo, News Editor, Guam Pacific Daily News  
Haidee Engenio, Reporter, Marianas Variety

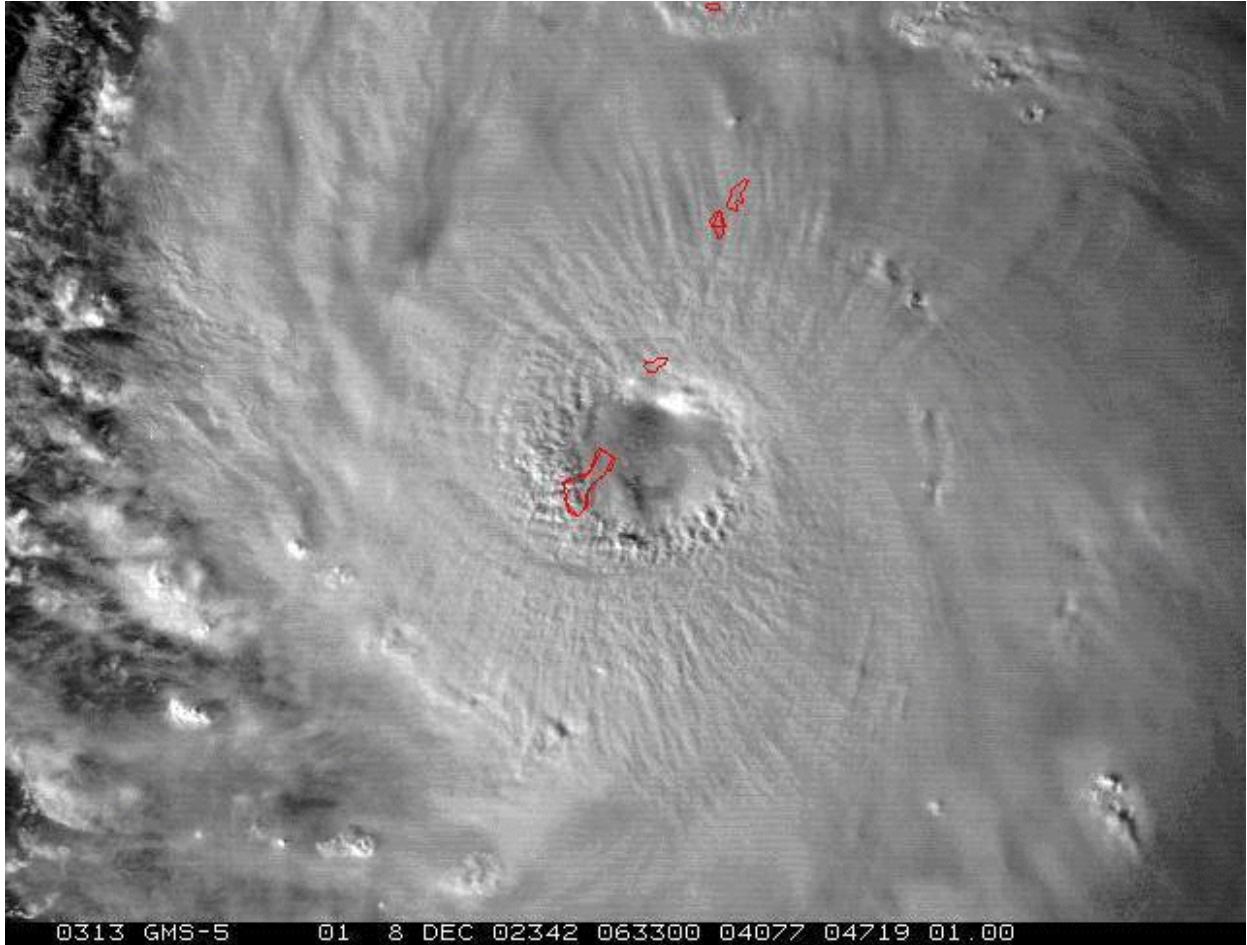
### **Private Sector Agencies, Institutions, and Organizations**

James Nelson, General Manager, Guam Visitor's Bureau  
David B. Tydingco, President, Guam Hotel and Restaurant Association  
David B. Arnold, Port Engineer, General Dynamics - American Overseas Marine  
Ralph Freeman, Chief Pilot, Continental Airlines  
Dr. Arthur Chiu, University of Hawaii

# Acronyms

AFB	Air Force Base
ASOS	Automated Surface Observation System
CNMI	Commonwealth of Northern Mariana Islands
COR	Conditions of Readiness
EAS	Emergency Alert System
FSM	Federated States of Micronesia
GMS	Geostationary Meteorological Satellite
HF	High Frequency
JMA	Japan Meteorological Agency
JTWC	Joint Typhoon Warning Center
mb	millibars
MIC	Meteorologist in Charge
NOAA	National Oceanic and Atmospheric Administration
NWR	NOAA Weather Radio
NWS	National Weather Service
PEACESAT	Pan-Pacific Education and Communication Experiments by Satellite
RSMC	Regional Specialized Meteorological Center
SAME	Specific Area Message Encoder
SDM	Station Duty Manual
SOO	Science and Operations Officer
TD	Tropical Depression
TS	Tropical Storm
UTC	Coordinated Universal Time
WCM	Warning Coordination Meteorologist
WFO	Weather Forecast Office
WSR-88D	Weather Surveillance Radar-1988 Doppler





Visible satellite image of Pongsona as seen by the Japanese Geostationary Meteorological Satellite (GMS-5) at 4:30 p.m., December 8, 2002. The island of Rota is located just north of the eye. (Courtesy of the Wisconsin Co-operative Institute for Meteorological Satellite Studies)



Damage to a commercial warehouse across from the Governor's Complex in Adelup, Guam. (NOAA)



Remains of the units of the Micronesia Hotel along Route 8 in Mongmong-Toto-Maite, Guam. (NOAA)

# Service Assessment Report

## Executive Summary

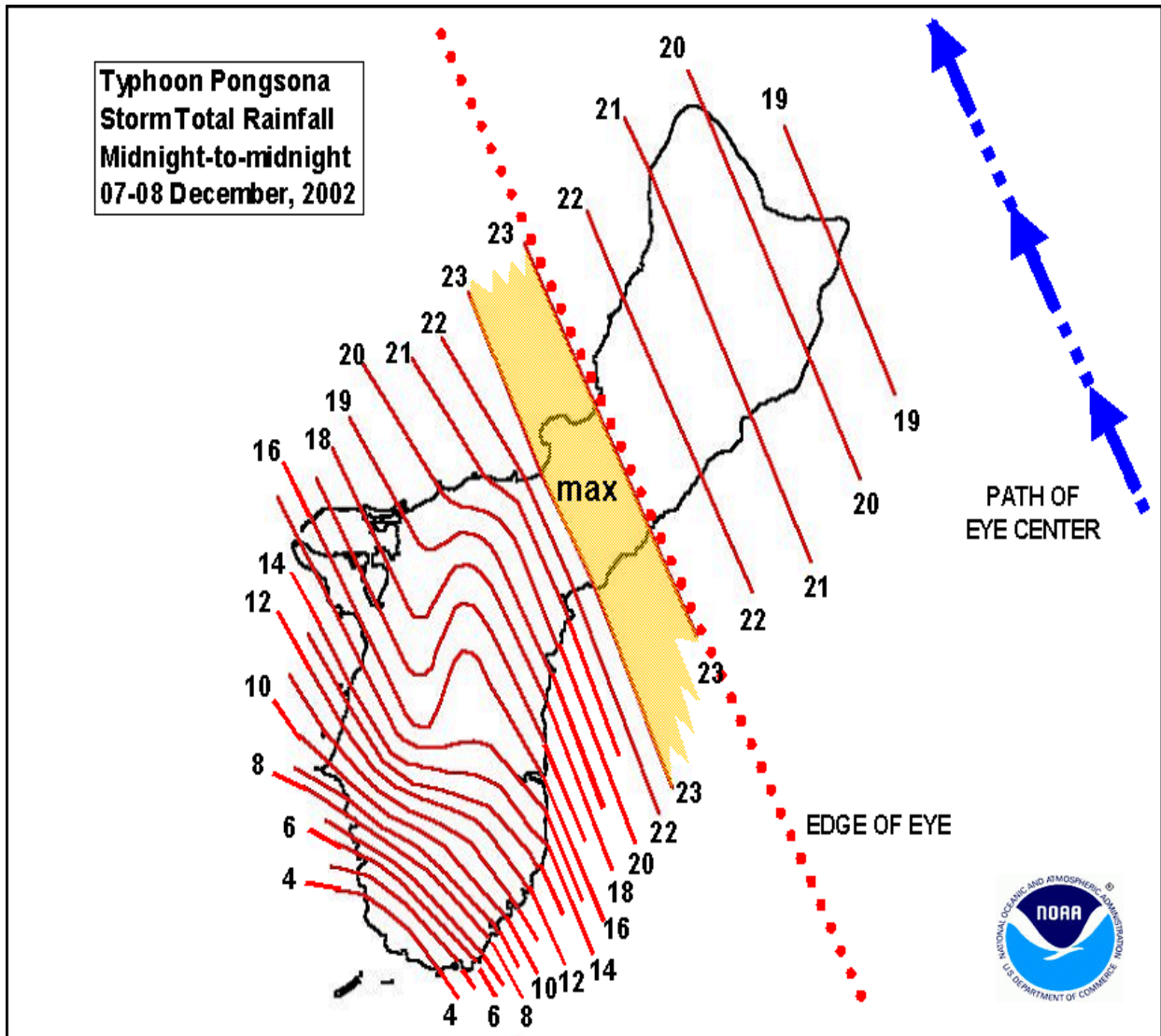
Super Typhoon Pongsona was one of the worst typhoons to ever strike the island of Guam. It was Guam's third most intense storm with sustained winds of 144 miles per hour (mph), gusts to 173 mph, and a pressure of 27.61 inches (935 millibars [mb]). Only two storms exceeded Super Typhoon Pongsona—Karen in 1962, 27.52 inches (932 mb) and 155 mph winds sustained; and the Typhoon of 1900, 27.35 inches (926 mb), wind speed unknown. Super Typhoon Paka in 1997 equaled Pongsona in intensity while over Guam. Preliminary damage estimates for Guam totaled more than \$700 million which placed Pongsona in the top five typhoons for damage.

There was one indirect death attributed to the storm; a woman was cut by flying glass and subsequently suffered a fatal heart attack. Medical help could not reach her due to the intensity of the storm. The Guam Department of Health reported 193 injuries, mostly lacerations and fractures caused by flying glass and other debris. Deaths and injuries were kept to a minimum due to the public's experience with typhoons and Guam's strong building codes. The eyes of six typhoons have passed over Guam in the past 10 years. Watches and warnings issued by the Weather Forecast Office (WFO) Tiyan, Guam, gave the population significant lead time, although the intensity of the storm on the island was under forecast. (Hereafter, WFO Tiyan, Guam, is referred to as WFO Guam.)

The eye of Pongsona was unusually large, almost 40 miles in diameter, and passed over the northern part of Guam. (See Appendix A for Guam Locations.) Andersen Air Force Base (AFB) was in the eye for nearly 2 hours. Conditions in the eye are characterized by light winds with little or no rain. The strongest winds in a typhoon are in the eyewall immediately surrounding the eye. The storm's track kept the eyewall over the most populated and developed part of the island, with typhoon force winds and torrential rains for as much as 5 hours. Rainfall amounts exceeded 20 inches over some areas in the north with a maximum of 25.61 inches at the University of Guam. (See *Figure 1* for rainfall totals.) Since such a large portion of the population experienced the worst part of the storm, there was a perception this was the worst typhoon to ever strike Guam.

Despite the Joint Typhoon Warning Center (JTWC) forecasts that Super Typhoon Pongsona would miss Guam, WFO Guam issued timely watches and warnings. (See Tropical Cyclone Forecast Responsibility in the Western North Pacific Ocean section below.) The storm struck Guam with greater intensity than forecast, resulting in a public perception the forecast was not good. This is discussed in more detail in the report.





**Figure 1:** Total rainfall (in inches) midnight-to-midnight December 7-8, 2002. Maximum rainfall occurred in a swath across central Guam that experienced the heaviest rain rates for the longest possible time. Areas in the northeast spent as much as 2 hours in the eye, and rainfall totals were slightly less there. Also, rainfall totals dropped off rapidly to the southwest because of increasing distance from the eye wall and decreasing time spent within the region of high rain rates. (NOAA)

WFO Guam has an excellent working relationship with the local government and the media. John F. Blas, Executive Director of the Mayors Council on Guam, complimented the National Weather Service (NWS) performance, saying, “*The NWS did a better job with Pongsona than with Chata’an*” (in 2002), and he was “...*very happy with the NWS.*” The media’s reaction to NWS performance was mixed. The consensus was the NWS does a good job, however, this forecast could have been better.

Service assessments are undertaken by the NWS to determine the level of service provided to its partners and customers. Service lapses, if any, are noted so corrective action can be taken. Emergency managers, civil defense, people in the media, and local residents were interviewed to obtain feedback on NWS performance.

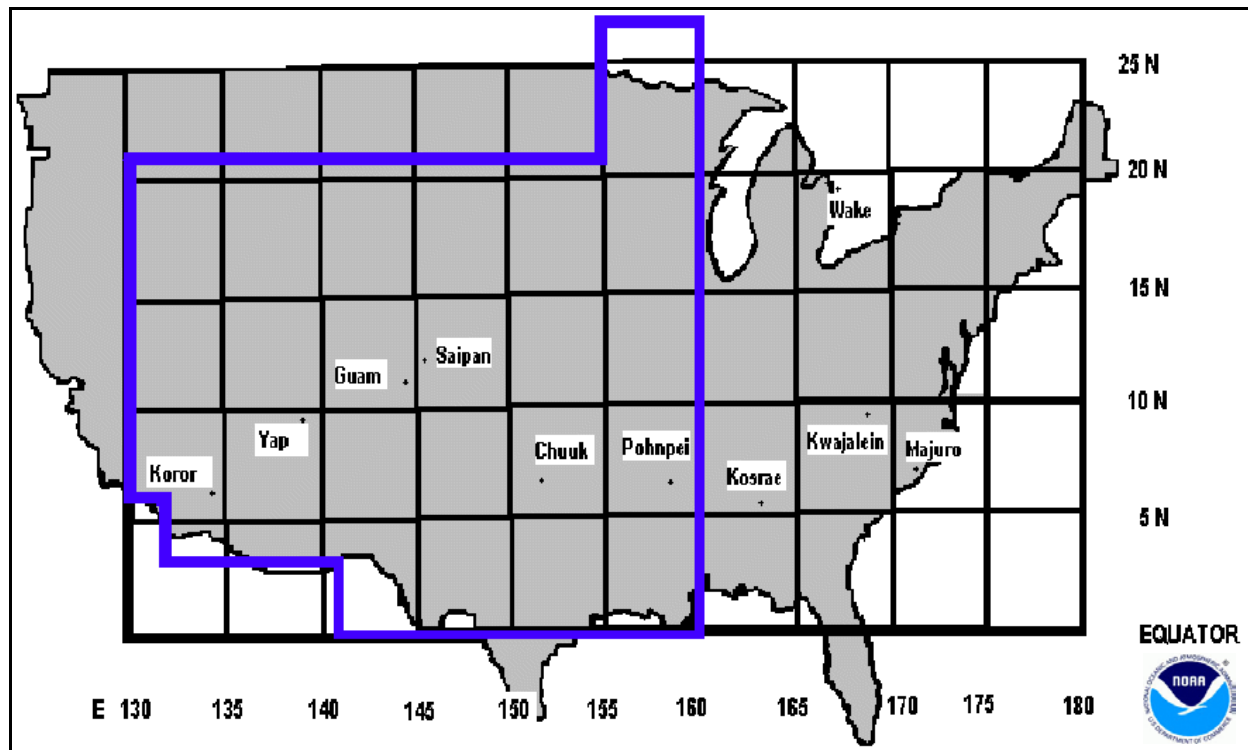
WFO Guam’s area of responsibility for tropical cyclone watches and warnings includes the island of Guam (U.S. Territory), the Northern Mariana Islands (U.S. Commonwealth), Wake Island (U.S. unincorporated Territory), the Federated States of Micronesia (FSM), the Republic of the Marshall Islands, and the Republic of Palau (the latter three all independent nations). The assessment focused on service provided to partners and customers.

The assessment team learned WFO Guam did a good job in communicating information as track and intensity forecasts changed and provided excellent coordination to partners in government and the media. WFO Honolulu provided excellent backup when communications on Guam failed. The team found opportunities for improvement, and developed eleven recommendations pertaining to communications, dissemination, science, and internal and external procedures.

Data contained in this report were compiled by the assessment team as of March 11, 2003. Final analyses may produce statistics that do not match those contained in this report.

## **Tropical Cyclone Forecast Responsibility in the Western North Pacific Ocean**

Tropical cyclones, with maximum sustained winds greater than 73 mph, are called typhoons in the western North Pacific Ocean. This area is bounded by the equator to the south, Asia to the west, the limit of tropical cyclone activity to the north, and the International Date Line to the east. The Regional Specialized Meteorological Center (RSMC) of the Japan Meteorological Agency (JMA) has international responsibility for monitoring and forecasting tropical cyclones. The NWS uses the names assigned to tropical cyclones by RSMC, but does not use its forecasts. JTWC at Pearl Harbor, Hawaii, is responsible for monitoring and forecasting tropical cyclones for American military interests. These forecasts are also the basis for WFO Guam’s public tropical cyclone advisories, watches, and warnings for its area of responsibility (see *Figure 2*).



**Figure 2:** The WFO Guam area of responsibility, compared with the size of the continental United States. Area bordered in blue represents aviation area of responsibility. Area bordered in black represents tropical cyclone area of responsibility. (NOAA)

## Chronology

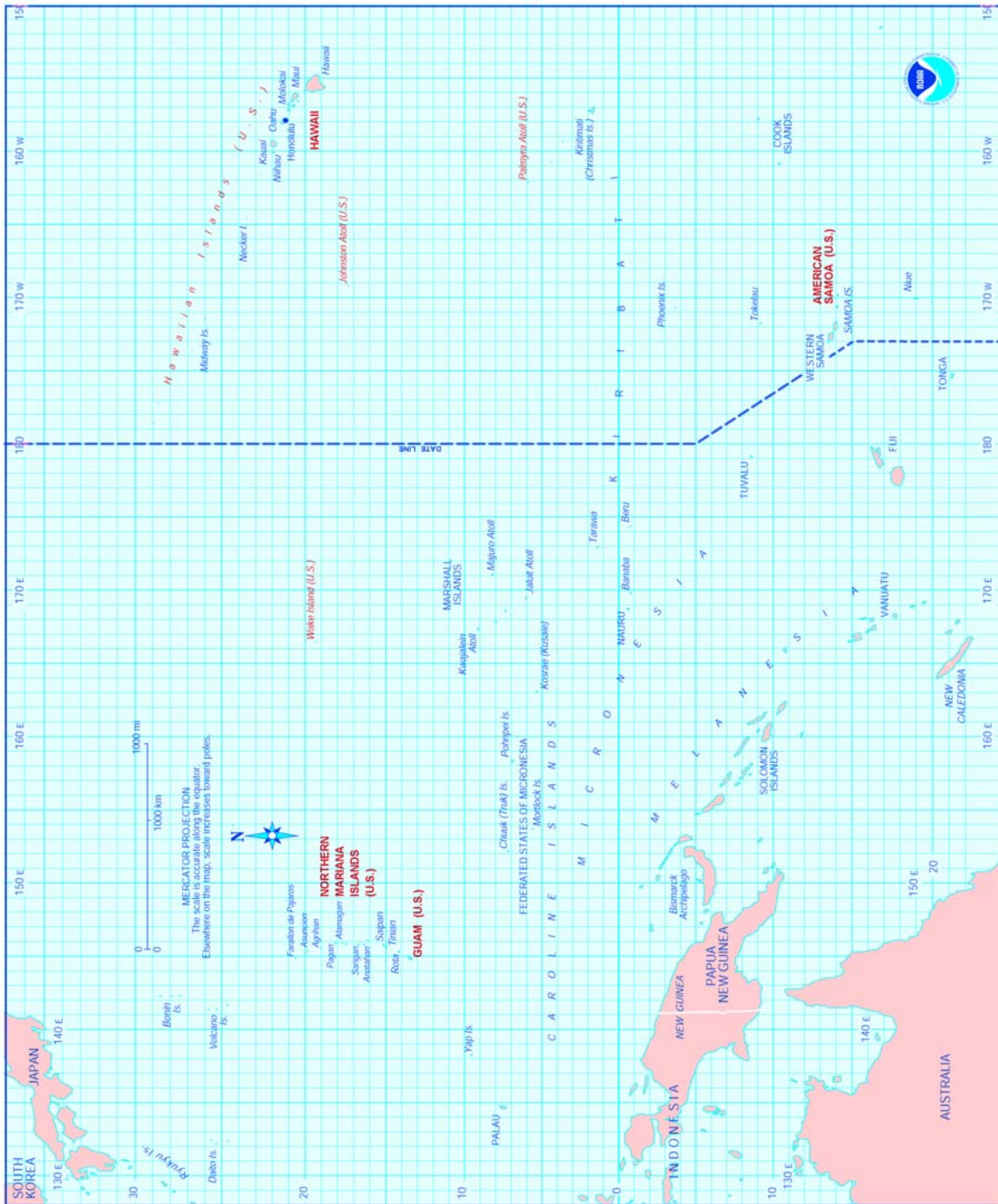
The locations of JTWC, Guam, and other places in the Pacific mentioned in this report are separated by enormous distances as well as the International Date Line (see *Figure 3*). For the reader to keep track of time, all times are referenced in Guam local time.

Super Typhoon Pongsona began as a weak disturbance about 370 miles east of Pohnpei (FSM). At 9 p.m., December 2, the JTWC issued a Tropical Cyclone Formation Alert, indicating the disturbance was likely to become a tropical cyclone within 12 to 24 hours. Seven hours later, JTWC issued the first warning on Tropical Depression (TD) 31W (31<sup>st</sup> tropical depression of the calendar year in the western North Pacific), located 70 miles north-northeast of the island of Kosrae (1,362 miles east-southeast of Guam). (See *Figure 4* for Super Typhoon Pongsona track.)

At 10 a.m., December 3, the JTWC upgraded the depression to Tropical Storm (TS) 31W. Twelve hours later, TS 31W was named Tropical Storm Pongsona by the RSMC. At 4 p.m., December 5, Pongsona was upgraded to a typhoon as it passed through Pohnpei State. Although it produced heavy rains and gusty winds, there was little damage. On December 6, the typhoon caused tropical storm force winds on Chuuk State (about 650 miles southeast of Guam) as it passed just north. High waves completely washed over some of the northwestern Atolls.

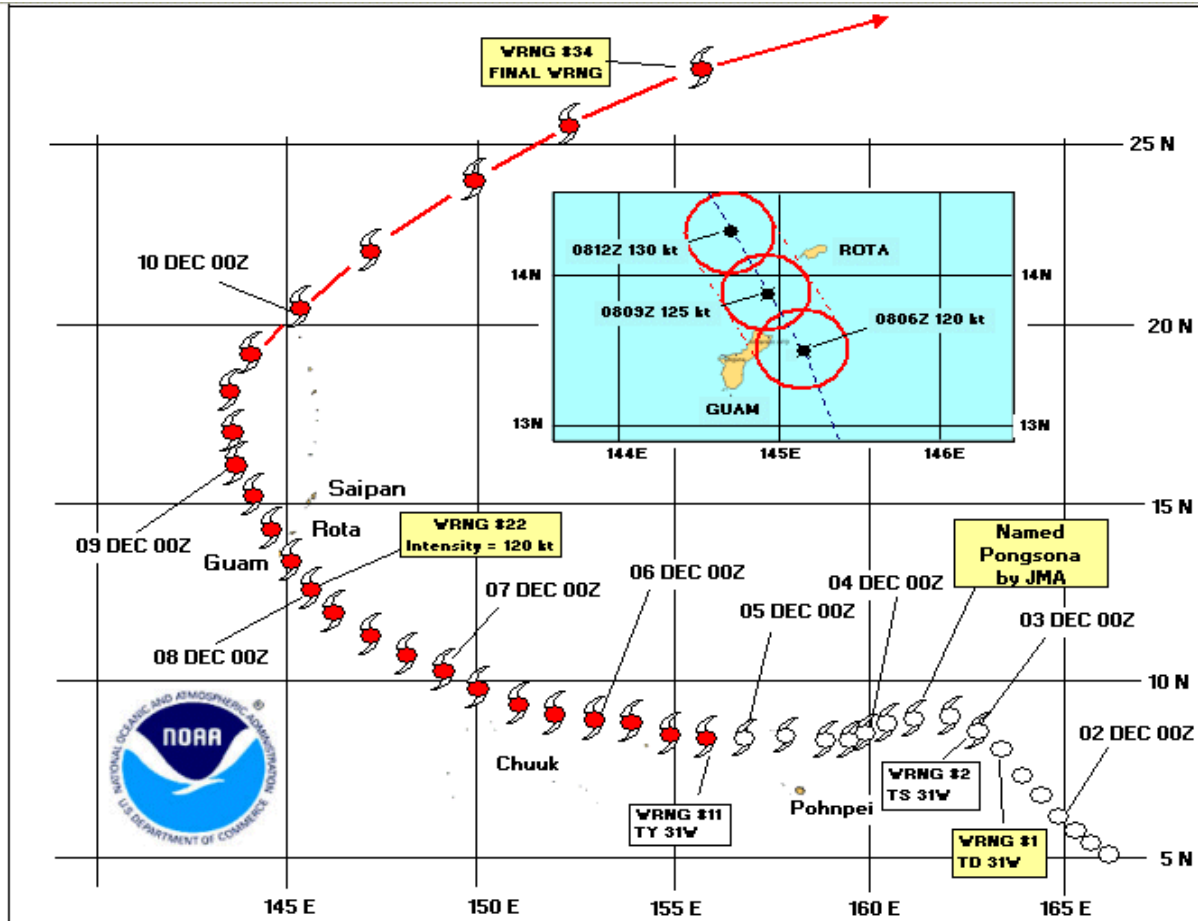
During the next two days, Pongsona continued to intensify and move on a west-northwest track. Late on December 7, the eye of the typhoon came into the range of the Andersen AFB Weather Surveillance Radar-1988 Doppler (WSR-88D), when it was about 270 miles southeast of Guam. Early on December 8, radar showed Pongsona beginning to recurve. (Most tropical cyclones move west or northwest and begin to turn to the north or northeast as they come under the influence of prevailing westerly winds at mid-latitudes.) The western half of the eye moved across northern Guam between 4:15 p.m. and 7:30 p.m. on December 8. Maximum sustained winds were estimated at 144 mph (converted from 125 knots) with higher gusts at both Hospital Point and Two Lovers Point on the west-central side of the island. (See *Figure 5* for peak wind gusts on Guam.)

Pongsona continued to intensify as it crossed Guam, and reached peak intensity of 150 mph at 10 p.m., December 8, while in the Rota Channel between Guam and Rota. Storms are classified as super typhoons when sustained winds reach 150 mph. On December 9, the typhoon began to weaken as it continued to recurve to the northeast. The storm lost its tropical characteristics on December 11.

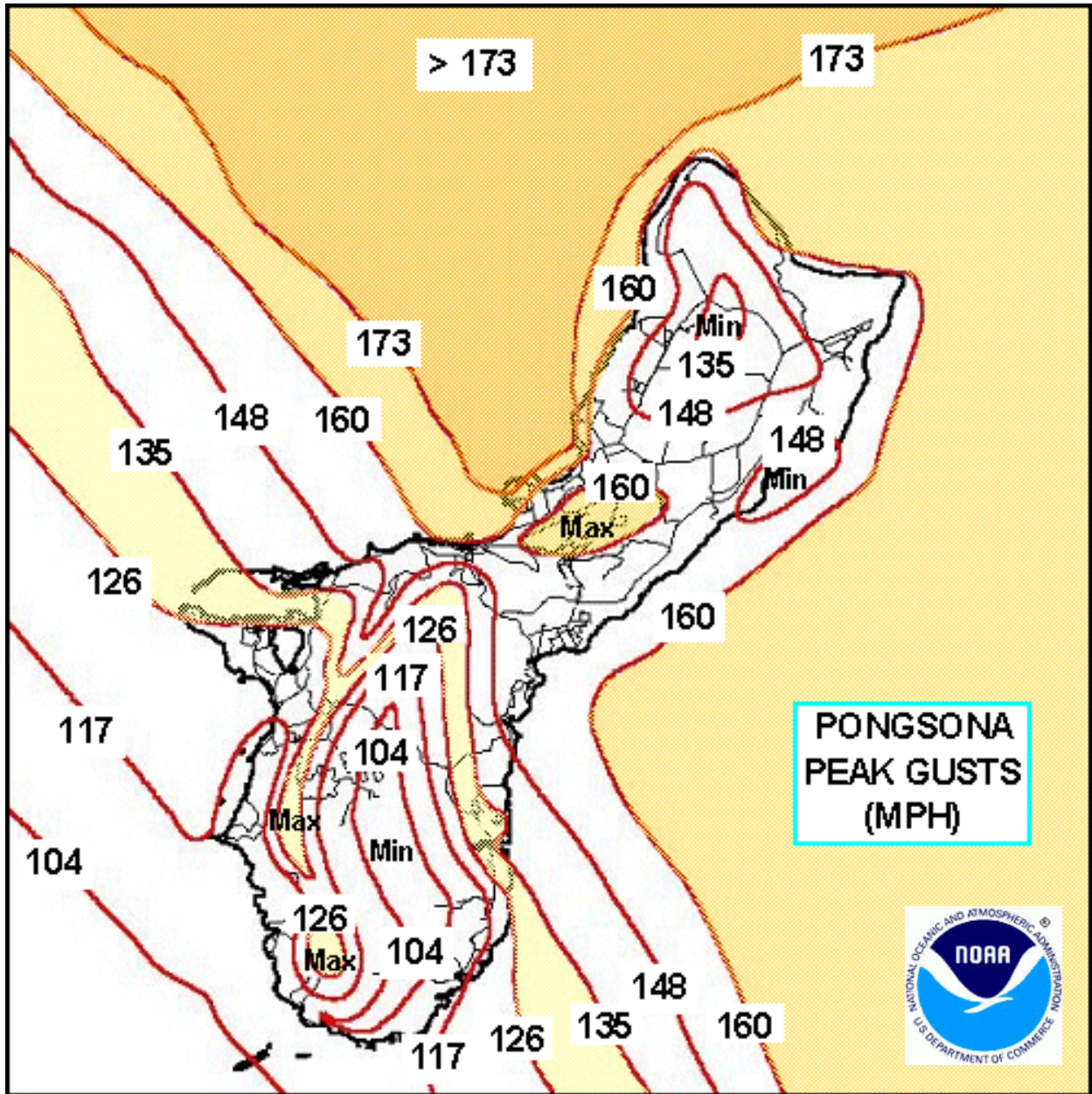


**Figure 3:** WFO Guam’s location in the western Pacific. (Courtesy of the American Red Cross)





**Figure 4:** Super Typhoon Pongsona’s track for December 1-11, 2002, as obtained from JTWC’s warning graphics. Looking at the track, the open circles are the tropical depression stage, the open center of the tropical cyclone symbol is the tropical storm stage, and the red center is the typhoon stage. Certain benchmarks in the life of Pongsona are indicated. The inset is a closeup of Pongsona’s passage between Guam and Rota. The three red rings are the approximate locations of the inner edge of the eyewall at 4 p.m., 7 p.m., and 11 p.m., December 8, 2002. The black dots are the positions of the eye center at these times. The intensities indicated are from the NOAA Meteorological Assessment of Super Typhoon Pongsona. (NOAA)



**Figure 5:** Distribution of Pongsona peak wind gusts on Guam on December 8, 2002. Contour values are in mph. (NOAA)

## Warning and Forecast Services

### WFO Guam

As mentioned in the Executive Summary, WFO Guam is tasked with issuing public tropical cyclone advisories, watches, and warnings for its large area of responsibility in the western North Pacific (see *Figure 2*). These products are based on JTWC forecasts of storm intensity and position. The office also issues the normal suite of WFO forecast and warning products, which become more frequent, longer, and more complex when a tropical cyclone threatens. The suite includes local statements when portions of the WFO area of responsibility are under tropical storm or typhoon watches or warnings. An additional tropical cyclone-related duty is the issuing of hourly position estimates when a cyclone's center is close enough to Guam to be accurately tracked on the WSR-88D radar at Andersen AFB.

As Pongsona became more organized and tracked west-northwest across the North Pacific, WFO Guam took the following actions (partial list):

- December 3, 2 p.m. — Tropical Storm Warning for portions of the Republic of the Marshall Islands.
- December 4, 8 p.m. — Tropical Storm Watch for Chuuk State, Federated States of Micronesia.
- December 5, 8 p.m. — Tropical Storm Warning for Federated States of Micronesia.
- December 6, 8 a.m. — Typhoon Watch for Guam, Rota, Saipan and Tinian in the Mariana Islands was issued for now Typhoon Pongsona.
- December 7, 8 a.m. — Typhoon Warning for Guam, Rota, Saipan and Tinian.
- December 7, 8 a.m. — Typhoon Watch for Agrihan, Commonwealth of Northern Mariana Islands (CNMI).
- December 8, 6 p.m. — Typhoon Warning for Agrihan, CNMI.

As Pongsona moved toward Guam, the WFO staff coordinated with the military and civil defense directors on Guam and in the Marianas. This coordination included participation in three “heavy weather briefings” for Guam held at 10 a.m., December 6, and 1 p.m. and 8 p.m., December 7. At the 8 p.m. briefing, based on the information from JTWC, the WFO staff continued to predict the eye would pass well to the east of the island and sustained typhoon force winds would remain offshore. This WFO forecast was for sustained winds of 60 to 65 mph with gusts to 75 mph (typhoon force). The forecast remained unchanged in the 11 p.m., December 7, local statement and included the following: “HOWEVER...A SLIGHT CHANGE IN THE

TYPHOON'S TRACK COULD BRING TYPHOON FORCE WINDS EXCEEDING 75 MPH ON SUNDAY [DECEMBER 8]." There would be a dramatic change just two hours later.

WFO Guam operates its typhoon warning program under a relationship with JTWC that is unique in the NWS. The NWS presence on Guam began in 1956 as a Weather Service Office (Taguac). In 1976, two NWS employees were assigned to the Naval Meteorology and Oceanography Center West. This facility provided weather services to both the civilian and military populations of Guam. In 1992, two more NWS employees were added to the staff. The Naval facility was closed in 1995 and the NWS assumed responsibility for providing all civilian weather services to Guam and Micronesia. In October 1997, Annex III to the Memorandum of Agreement between the Department of the Navy and the National Oceanic and Atmospheric Administration (NOAA) spelled out responsibilities for providing civilian weather services for Guam and surrounding areas. Included in this Annex was the requirement that JTWC "*act as sole forecast agency for tropical cyclones within its area of responsibility and, as appropriate, keep close liaison with the forecast office.*" The WFO Guam Station Duty Manual (SDM), section 5.1.1.5, states, "*The JTWC wind field forecast, in combination with the track forecast, is the basis for all watches and warnings.*"

The Warning Coordination Meteorologist (WCM) and the Science and Operations Officer (SOO) are both experienced forecasters who formerly worked at the JTWC. However, both, as well as a lead forecaster, were off-island as the typhoon approached and were unable to return until after the storm passed. The WFO Guam office policy is unclear in detailing the number of senior staff permitted to be off-island at the same time. **(Finding 1)**

Staffing on the day shift (8 a.m. to 4 p.m.) Saturday, December 7, consisted of two lead forecasters, one journeyman forecaster, a Hydrometeorological Technician (HMT), and the Meteorologist in Charge (MIC). The Guam shift log shows a call to JTWC sometime during the morning to coordinate the position of Pongsona, and questioned the difference between the forecast position and the satellite observed position. The evening shift staffing (4 p.m. to midnight) included three journeyman forecasters, an HMT, and the MIC, but no lead forecaster. It was unclear to the assessment team who was the designated lead forecaster. Interviews revealed the evening shift forecasters were all concerned the forecast track was too far east. This is supported by a shift log entry of a 10:30 p.m. call to the JTWC. However, this call was not made until the shift was almost over. The log entry also indicates JTWC forecasters agreed to re-evaluate the forecast track for their next advisory. (Note: JTWC issues regular tropical cyclone position and wind forecast updates every 6 hours at 1 a.m., 7 a.m., 1 p.m., and 7 p.m., respectively.)

Two lead forecasters were assigned to the midnight shift (midnight to 8 a.m.), Sunday, December 8. Interviews with the shift leader indicated when he came on duty, he was dismayed the forecast had remained the same for 8 hours, even though the typhoon had moved farther west than the JTWC had forecast. He stated the evening shift was a "critical shift" with respect to the forecast, and his experience taught him if a storm reached 150 degrees east longitude and remained at or below 10 degrees north latitude, then Guam was at "much greater risk." He

immediately called the JTWC (not in the shift log), was forceful in his concern about the forecast track, and told them he intended to make a significant increase in the wind forecast for Guam. He indicated the JTWC forecaster was reluctant to make a big change, but did agree to adjust the forecast. The shift log shows a call from JTWC at 12:30 a.m. on December 8, noting reception of a “new warning.” The forecaster then called the Guam Civil Defense informing them the forecast track was farther west and typhoon force winds would affect Guam. This was 30 minutes before JTWC issued the routine forecast at 1 a.m. Guam’s 1 a.m. typhoon local statement included: “NORTHEAST WINDS WILL INCREASE THROUGHOUT THE DAY TODAY AND REACH 90 TO 115 MPH WITH GUSTS TO 130 MPH BY THIS AFTERNOON. WINDS THIS STRONG WILL BLOW DOWN NON-REINFORCED CINDER BLOCK WALLS. THE CENTER OF PONGSONA IS FORECAST TO PASS VERY CLOSE TO ROTA THIS EVENING.” At 4:45 a.m., a call was logged indicating JTWC forecasters were now expecting the typhoon center to pass close to Guam. At 6 a.m., the lead forecaster called the MIC about the expected eye passage. At 6:15 a.m., a shift log entry shows a telephone call to Guam Civil Defense with information conditions would be “*much worse, as we expect eye passage with 115-130 mph winds and gusts to 160 mph.*” At 7 a.m., JTWC made a final adjustment to the storm track, bringing the center of the eye just offshore. This brought the forecast track close to the actual track of the storm’s center. The 8 a.m. Tropical Cyclone Public Advisory from WFO Guam headlined, “POWERFUL TYPHOON PONGSONA BEARING DOWN ON GUAM AND ROTA.” The advisory also indicated the storm was continuing to intensify.

Based on the above information, the assessment team concluded a clearly designated lead forecaster on the Saturday, December 7, evening shift would have resulted in more proactive communication with JTWC and an earlier re-analysis of the forecast track. **(Finding 2)**

Lead times for the typhoon watch and warning for Guam and Rota were good. The typhoon watch was issued 47 hours before the onset of tropical storm force winds (39 mph or more—considered damaging wind speed) at WFO Guam (located in the center of the island) and 56 hours before the closest approach of the storm’s center to the island. While a large part of the eye crossed the island, the storm center itself remained offshore. The typhoon warning was issued 23 hours before the onset of tropical storm force winds at the WFO Guam and 32 hours before the closest approach of the storm’s center.

As Pongsona passed over Guam, the WFO experienced a breakdown in communications. The WFO could not receive phone calls from 6:10 p.m., December 8, to around 1 a.m., December 10. Communication with WFO Honolulu, Guam’s backup office, was limited to a satellite telephone that could not be used inside the WFO Guam building. Office staff actually went outside to call WFO Honolulu during the storm but didn’t wait to receive calls. **(Finding 3)** Guam staff used e-mail and its Web site until they failed. There were customer complaints about service slow downs on the Web site. This is discussed further in the Pacific Region Headquarters section of this report. Other communication issues are discussed in greater detail in the Communications section.

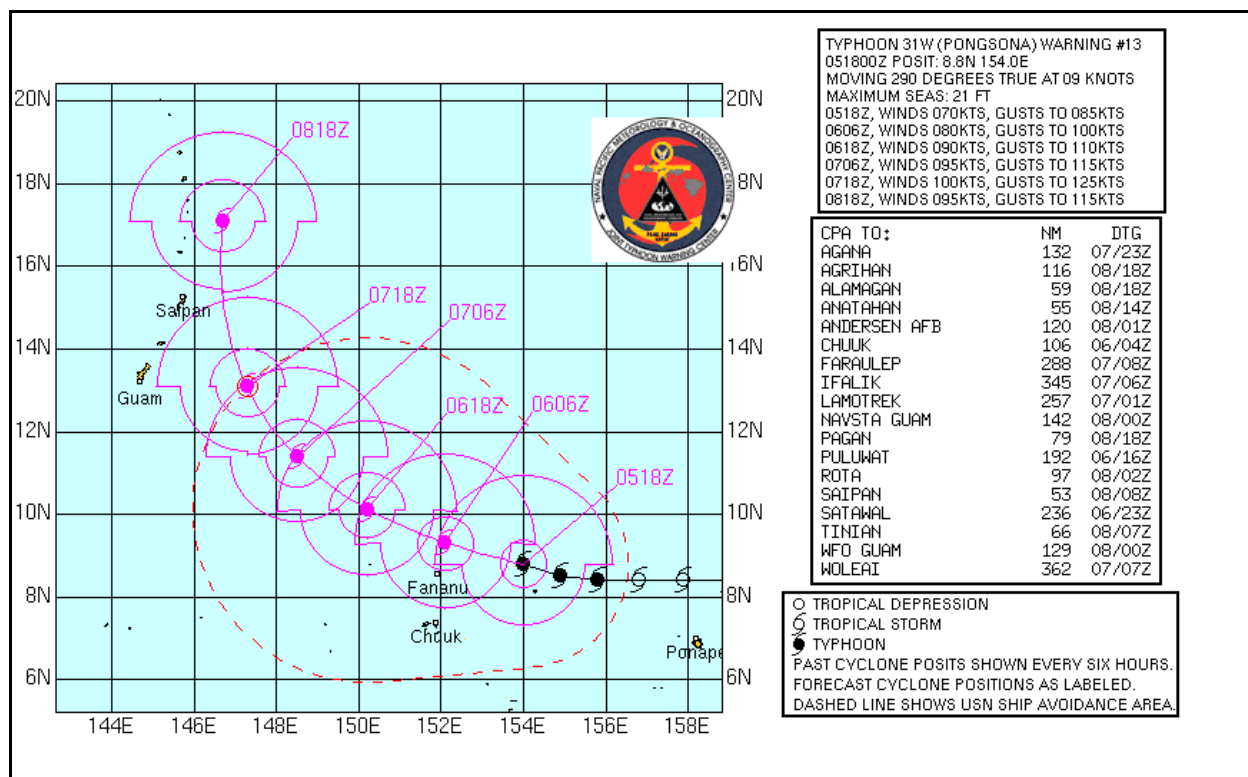
WFO Honolulu began partial backup by issuing aviation products at 4 p.m., December 8. The WFO Honolulu assumed all WFO Guam's duties 10 hours later. Backup responsibility was relinquished at 8:30 a.m., December 10. Additional information on WFO Honolulu's role is contained in the next section.

Neither WFO Guam nor JTWC issue tropical cyclone strike probabilities or any other product that displays the uncertainty in a tropical cyclone track forecast. The WFO does sometimes indicate a level of uncertainty by using statements in its advisories. For example, as stated above, the 11 p.m. local statement said, "HOWEVER...A SLIGHT CHANGE IN THE TYPHOON'S TRACK COULD BRING TYPHOON FORCE WINDS EXCEEDING 75 MPH ON SUNDAY [DECEMBER 8]." JTWC does issue a graphic depicting a "ship avoidance area" which is equivalent to an uncertainty forecast. (See *Figure 6*.) This product is intended for military use.

Instrument failure was another significant problem. The anemometer at Andersen AFB did work throughout the typhoon but wind speed data were unreliable. The four HANDAR wind sensors on Guam, which use sonic anemometers, all failed to report winds at the height of the storm. The HANDAR instruments began working again once typhoon conditions eased. The Service Assessment Report following Super Typhoon Paka in 1997 recommended re-siting or replacing wind instruments on Guam. Using the best knowledge and technology available at that time, the wind sensors on the four HANDAR units were replaced with sonic anemometers. Wind measurements were available from only one anemometer on the northern half of the island during passage of the eyewall. This was the Automated Surface Observation System (ASOS) anemometer. The Guam ASOS currently communicates data to the WFO via VHF transmitter. The system failed during Pongsona when the tower with the receiving antenna blew down.

**(Finding 4)**

The WSR-88D radar at Andersen AFB also failed during Pongsona due to loss of power. The backup generator had been malfunctioning for five months before Pongsona and had not been repaired. Another backup generator at the radar site required manual start-up but the base commander believed it was too dangerous to send a technician to the site. The U.S. Air Force told the assessment team the auto-start generator has now been repaired.



**Figure 6:** The JTWC forecast for Pongsona, valid at 4 a.m., December 6. The forecast positions are labeled with date and time as 2 digits each, respectively. “Z” corresponds to Coordinated Universal Time (UTC), Guam time minus 10 hours. Dashed line represents ship avoidance area. (Courtesy of JTWC)



## **WFO Honolulu, Hawaii**

WFO Honolulu is the backup office for WFO Guam. When backup procedures are in effect, WFO Honolulu is responsible for issuing all WFO Guam products, including tropical cyclone products. WFO Honolulu began its backup responsibility with aviation products at 4 p.m., December 8, and took over all WFO Guam duties at 2 a.m., December 9. WFO Honolulu ended its backup responsibility by 8:30 a.m., December 10. The WFO Guam lead forecaster who was off-island worked shifts at WFO Honolulu during this backup period. The assessment team also found the two WFOs did not hold backup drills during 2002.

While in backup mode, WFO Honolulu issued typhoon warnings for CNMI at 2 a.m., December 9. WFO Honolulu discontinued typhoon warnings as Pongsona moved past individual islands in the Marianas. The warnings for Alamagan and Agrihan were cancelled 5 hours before the closest approach of Pongsona. In interviews with WFO Guam staff, some forecasters expressed concern warnings were cancelled too early. The Saipan emergency manager agreed. **(Finding 5)**

## **Pacific Region Headquarters**

Pacific Region Headquarters in Honolulu, Hawaii, provides administrative and technical support to field offices in its region.

The WFO Guam Web site is hosted on a shared server located at the Telecommunications Operations Center at NWS Headquarters in Silver Spring, Maryland. As mentioned earlier in this report, the assessment team heard complaints from the public about the Web site's slow response. In addition, limited disk space resulted in an inability to update WFO Guam's Web page. This problem of limited disk space lasted 3 hours until Pacific Region staff deleted files. The assessment team learned Pacific Region is in the process of upgrading server capabilities which should resolve the problems of slower response and limited disk space.

## **Joint Typhoon Warning Center**

Note to the casual reader: this section contains detailed technical information about forecast errors.

Tropical cyclone forecasts in the western North Pacific issued by the JTWC are the basis for Guam's tropical cyclone watches and warnings. The JTWC issues 6 hourly advisories, including forecast track, wind speed, and wind radii (distance from the storm center of tropical storm force and typhoon force winds). A discussion of the meteorological aspects of the tropical cyclone is issued every 12 hours.

Military forecasters serve a 3-year tour of duty at JTWC. Hurricane/typhoon forecasters in civilian national meteorological services typically have more experience. JTWC forecasters



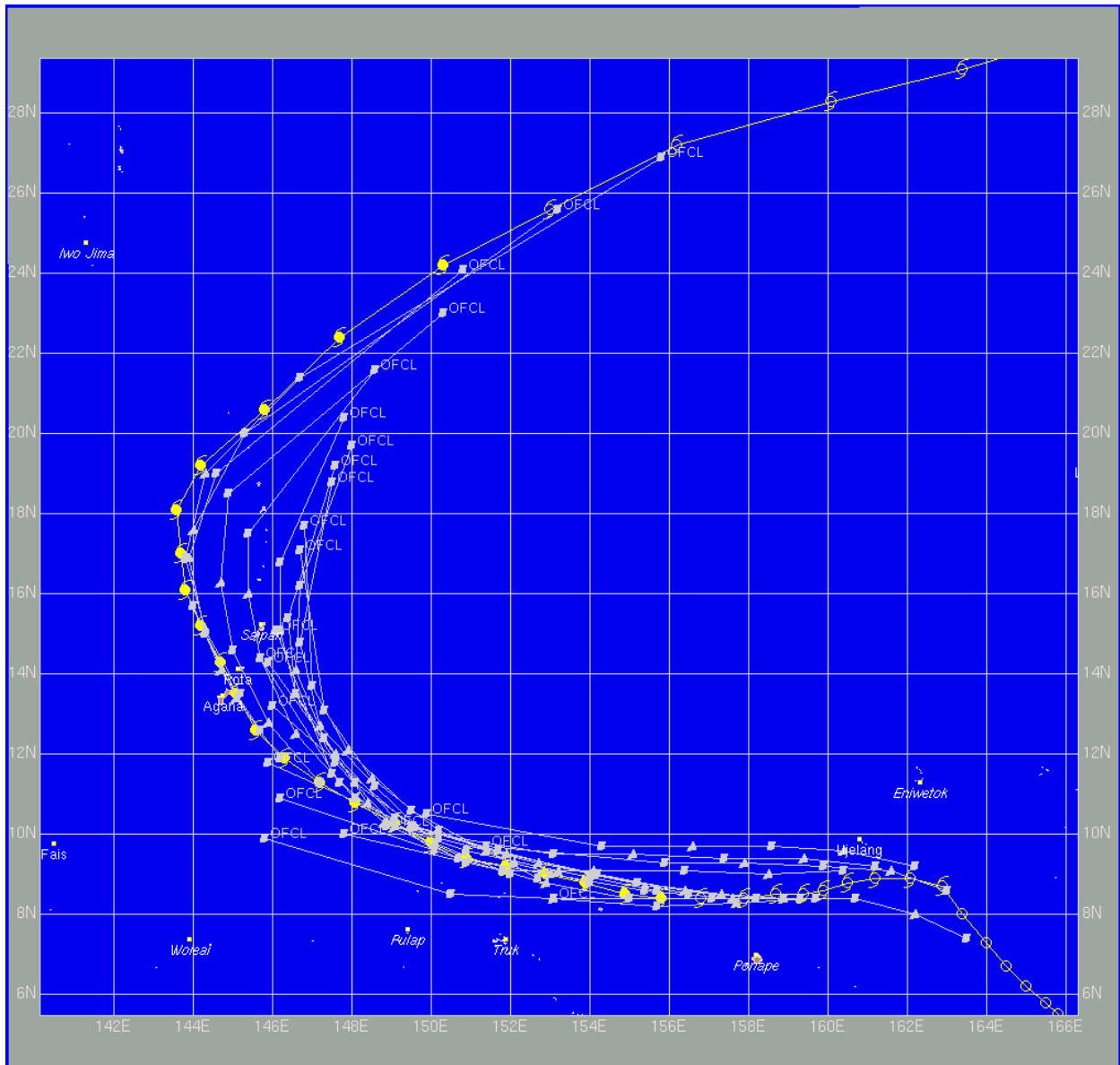
follow a specific process in preparing typhoon track and intensity forecasts which place a heavy reliance on guidance from computer models. Computer models, and the forecasts based on it, were consistent in placing the storm track too far east of Guam in the 2 days prior to landfall. (See *Figure 7*.)

The JTWC track forecasts for the three days leading up to Pongsona's passage across Guam were much better than JTWC's forecasts for all tropical cyclones for the period 1997-2001. The average position error for 24-hour forecasts for Pongsona was 59 miles versus the 5-year average of 109 miles. The average position error for 48 hours was 97 miles versus the 5-year average of 171 miles. For 72 hours, the position error for Pongsona was 124 miles versus 285 miles for the period 1997-2001. Note the 72-hour forecast position error for Pongsona was smaller than the 48-hour error for the 5-year period mentioned above, and the 48-hour forecast position error for Pongsona was smaller than the 5-year average for 24 hours.

Despite JTWC's above average track forecasts, the fact that a direct hit from a major typhoon was not forecast resulted in below average service to the population of Guam. As mentioned above, the average forecast position error for all 72-hour forecasts was 124 miles. The position error for the 72-hour forecast verifying at the time the storm was over the island was 64 miles. The average 48-hour forecast position error was 97 miles, but the 48-hour forecast position error for the time the storm was over the island increased to 121 miles. The 24-hour forecast position error for the time the storm was over the island was 95 miles versus the average error for all 24-hour forecasts of 59 miles.

While JTWC did forecast intensification of the storm, the trend was underestimated. In the three days prior to landfall, JTWC consistently under forecast storm intensity by almost 30 mph. For example, the Thursday evening, December 5, forecast indicated a maximum sustained wind of 115 mph for Sunday afternoon, December 8 (the time the storm was over Guam). The actual maximum sustained wind was estimated at 144 mph.

Analysis of satellite images by the assessment team indicated 24 hours prior to landfall, the storm was undergoing significant intensification as it continued to track farther west than forecast. However, as late as 12 hours before landfall, JTWC forecasters continued to underestimate the threat to Guam. The WFO Guam lead forecaster on the midnight shift, December 8, called JTWC shortly after midnight to urge a modification in the forecast track. This forecaster told the assessment team he was convinced Super Typhoon Pongsona was going to pass close by or make a direct hit on Guam. This forecaster stated he sensed a reluctance on the part of JTWC to make a major change in the forecast track. **(Finding 6)**



**Figure 7:** A composite of JTWC track forecasts for Super Typhoon Pongsona from the first advisory until it recurved northeast and lost tropical characteristics. Six hourly track forecasts are in grey, with markers at 12, 24, 36, 48, and 72 hours. The actual “best” track of Pongsona is shown in yellow, with markers every 6 hours. (Courtesy of JTWC)

## Partners and Customers Coordination

The effectiveness of the weather warning system is dependent on close coordination, cooperation, and a clear consistent message among the various agencies responsible for public safety. This includes the NWS, the media, Guam Civil Defense, and other government entities.

Feedback from partners and customers varied. Some in government and media interviewed by the assessment team said they were satisfied or very satisfied with the forecast. These people are aware of the uncertainties in typhoon forecasting, and knew any change in the track and intensity of a tropical cyclone that close to Guam could have a major impact. Others said they were not properly informed about the track and intensity of the super typhoon and were not prepared for a direct hit.

## Civil Defense/Emergency Management

WFO Guam has a close working relationship with Guam Civil Defense. Leo Espia, Guam Civil Defense, said, “*Civil Defense maintains good communications with NWS. NWS calls Civil Defense on a routine basis.*” During the Pongsona threat, the WFO Guam MIC was in frequent phone contact with Guam Civil Defense.

Civil defense officials told the assessment team they often use the NWS and JTWC Web sites. They also used HURREVAC software as Pongsona was approaching the island. HURREVAC is a restricted-use U.S. Government program used by emergency managers and civil defense officials since 1988 to track hurricanes and assist in decision making for their communities.

During tropical cyclone events, WFO Guam participates in heavy weather briefings at Civil Defense Headquarters, attended by government representatives and the media. There were three heavy weather briefings for Super Typhoon Pongsona, prior to civil defense activation of COR 1. Guam Civil Defense uses Conditions of Readiness (COR). COR is used by the military to indicate the period between current time and onset of damaging winds (greater than 39 mph). COR levels 4, 3, 2, and 1 correspond to the onset of damaging winds in 72, 48, 24, and 12 hours, respectively. (See Appendix B.) COR was adopted by the Guam Civil Defense and is understood by Guam’s general population, because until 1995 the military forecast the weather for Guam. The emergency response system on Guam is keyed to changes in COR levels and not to NWS tropical cyclone watches and warnings. **(Finding 7)**

There were differing opinions concerning the relationship of COR to watches/warnings. Random interviews with the public indicated several people were confused about the different terms used by Guam Civil Defense and the NWS. Because of the long military presence, some are familiar with COR and do not understand NWS watches and warnings. Mr. David Tydingco, Hotel and Restaurant Association, stated, “*The NWS watch and warning terminology—people don’t know how to take it.*” In contrast, Mr. James Nelson of the Guam Visitor’s Bureau said there was no confusion about COR levels.

Guam Civil Defense is an active participant at WFO Guam workshops and coordination meetings. Civil defense officials participated in the annual typhoon exercise (fictitious Pakyo 2002), annual typhoon workshops, and joint NOAA/Federal Emergency Management Agency courses on typhoons.

CNMI emergency management praised NWS performance. Mr. Anthony Calvo, CMNI Emergency Manager, indicated although the actual intensity of the storm was greater than expected and the damage was *“incredible,”* he was satisfied with the information received from the NWS. He stated, *“...very good information from NWS; we were not caught off-guard.”*

## **Government of Guam**

Several local government agencies were interviewed by the assessment team. A key partner in the warning process is the Guam Council of Mayors. The mayors assist in notifying people in their communities, sometimes driving through villages using portable public address systems to announce typhoon warnings. Members of the Council are active participants in WFO Guam workshops and briefings and receive NWS products by facsimile several times a day. During Super Typhoon Pongsona, the Council used HURREVAC to evaluate the typhoon’s threat to Guam. The Executive Director of the Mayors Council, John F. Blas, said, *“The NWS did a better job with Pongsona than with Chataon.”* He went on to say he was *“very happy with the NWS.”*

According to James Nelson, General Manager, Guam Visitors Bureau, there were 10,000 visitors on Guam before Pongsona struck. Mr. Nelson said WFO Guam in general *“is doing the job very well.”* However, he noted the forecast projections for Pongsona were off this time. He commented people were relaxed on Saturday morning, December 7, with some choosing to ignore the warnings.

Frank Santos, Guam’s Port Authority Harbor Master, said *“people were expecting a banana typhoon”* with winds of 50 to 60 mph. (In the tropics, a “banana typhoon” refers to winds strong enough to blow down banana trees but not do major damage.)

## **Private Sector**

Most of the major hotels in Guam are members of the Hotel and Restaurant Association, a non-profit trade group which has actively participated in WFO Guam typhoon workshops and other briefings. Mr. David Tydingco, President, explained the association has an emergency action plan, ensuring all the hotel properties receive weather bulletins. One of the member hotels (Pacific Island Club) receives the weather bulletins from NWS via facsimile and then releases the information to other hotel members. Mr. Tydingco said the forecast for Super Typhoon Pongsona was off and led people to be too relaxed and complacent.

## Media

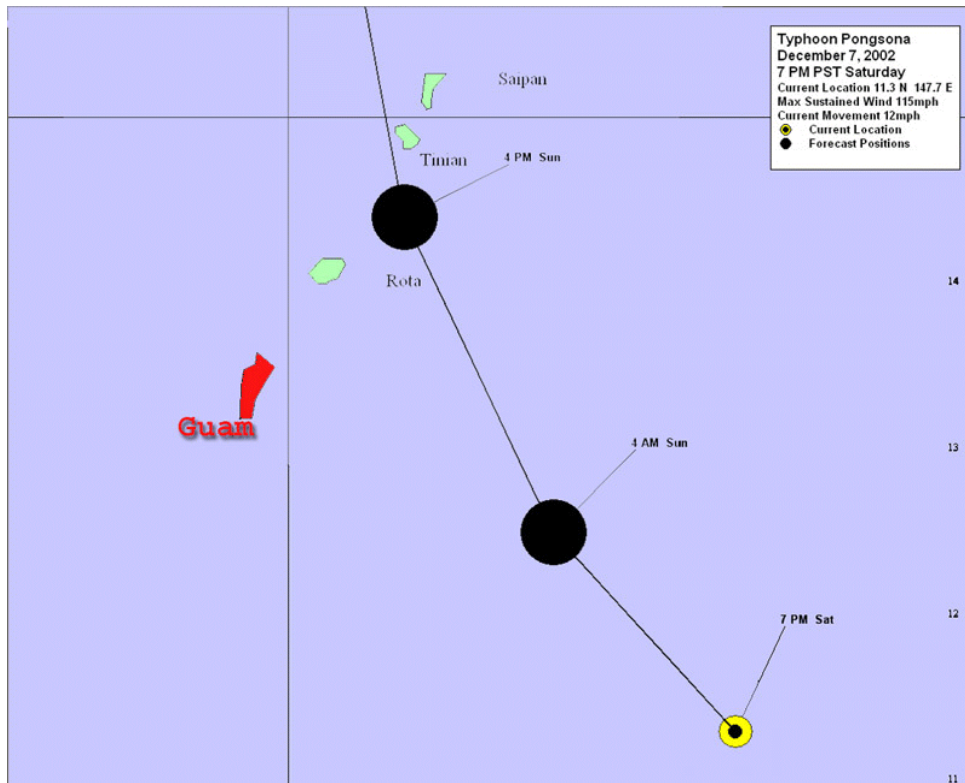
Guam is served by one major daily newspaper, four television stations, and eleven radio stations. Two smaller daily newspapers published in CNMI are also available on Guam.

WFO Guam began media outreach in 1995 when it assumed responsibility for issuing weather forecasts from the military. A concerted effort was made to educate the media about NWS products, including watch and warning definitions, and safety preparedness via regular briefings and publications. In 1996, WFO Guam instituted an annual typhoon workshop for media and civil defense. Comments by the media to the assessment team showed WFO Guam has developed a strong working relationship. NWS products are faxed to all broadcast and major print media on Guam.

Guam media is proactive about covering weather and relaying NWS information to the public. Most of the media interviewed use the NWS and JTWC Web sites.

Guam's main newspaper, Pacific Daily News, regularly advertises the WFO Web site and phone numbers for recorded weather information, including a phone number for the NOAA Weather Radio (NWR) broadcast. During typhoons, the paper provides extensive coverage, including preparedness information, and an explanation of watches and warnings. Lee Webber, Publisher of Pacific Daily News, advocated the development of graphics to give the public a better idea how the typhoon track might vary. Mr. Webber said, *"Explaining things graphically is better than telling. It would be good to have a graphic showing the strike probabilities and margin of error. People would take more heed."*

One television station, KUAM-TV, produces live daily news programming and weather segments, but is off the air from midnight to 6 a.m. KUAM-TV did not come back on the air Sunday morning, December 8, because the antenna blew down during the night. The other three stations broadcast taped-delayed programming and cable channels, but KTGM-TV breaks in as necessary to report weather updates. Several radio stations operate around the clock but broadcast taped programming after midnight. Newspapers have print deadlines that cannot be changed. The Pacific Daily News goes to print at 11 p.m. Since the significant change to the typhoon forecast came at 1 a.m., Sunday, December 8, these media outlets could not disseminate the information. For example, the Sunday morning edition of the Pacific Daily News showed the forecast as of 11 p.m., Saturday night, December 7, which indicated the typhoon tracking east of Guam when the forecast already been changed to bring the storm over the island (see *Figure 8*). However, newspaper staff did post updates on the Pacific Daily News Web site and responded to calls from the public seeking information.



**Figure 8:** This is a copy of the JTWC track forecast published by the Pacific Daily News, Sunday morning, December 8, 2002. Yellow circle represents the storm position at 7 p.m., Saturday, December 7. Black circles represent forecast positions at 4 a.m. and 4 p.m., Sunday, December 8, respectively. (Courtesy of JTWC)

The Guam media recognized the efforts of WFO Guam and understood the limitations of typhoon forecasting. K57 AM Radio Jon Anderson, President, Sorenson Pacific Broadcasting, Inc., said, *“I don’t have any problems with the forecasts issued by NWS. I think it was handled well.”* KSTO Radio, Edward Poppe, President, Inter-Island Communications, Inc., said, *“You guys did a wonderful job.”*

## **Public**

One theme stood out in assessment interviews with the public: people did not receive advanced warning of a storm of Pongsona’s intensity.

- Several people referred to the expectation of a banana typhoon and not the intensity of a super typhoon.
- Tracking graphics published in the newspaper each day consistently placed the typhoon east of the island. As mentioned in the Media section, the Sunday morning graphic of the forecast storm track, the day the storm struck, showed the typhoon passing east of Guam. One person said, *“It was not that people did not prepare adequately. The actual track was the problem and the way it was communicated.”*
- Interviews indicated people accept track and intensity forecasts as accurate. There are no products which indicate the inherent uncertainty in these forecasts.
- Several people interviewed reported radio stations downplayed the strength of the typhoon (based on the forecast) by encouraging the public to go shopping and take in a movie.
- The storm was also downplayed on KUAM-TV when a government official announced in a live interview on the 6 p.m. news, Saturday night, December 7, that COR 1 would be declared at midnight but *“we don’t expect it to be a bad storm.”* **(Finding 8)**

The December 21, 2002, issue of the Pacific Daily News published the results of a survey about satisfaction with NWS information during Pongsona. Out of 350 responses, 42.2 percent said they were not satisfied with NWS information during Pongsona, while 20 percent expressed satisfaction. (See Appendix C for newspaper survey.)

WFO Guam has been proactive in community outreach activities. During the past four years, there have been more than 20 public safety presentations, more than a dozen island-wide awareness programs, numerous media contacts, school talks, and efforts at establishing partnerships with the private sector for printing and distributing NWS brochures.

## Communications

WFO Guam uses conventional facsimile as the principal product dissemination method. Products are faxed to media, civil defense, the hotel association, Council of Mayors, the military, the airport, government agencies such as the Federal Aviation Administration, the Port Authority, and other users. If the island phone lines fail during severe weather events, WFO Guam may not immediately be aware faxes are not being received. During Pongsona, the WFO also provided updated information by cell phone and Internet.

## Emergency Alert System

During Pongsona, the Governor of Guam maintained control of the Emergency Alert System (EAS). There was no signed EAS Plan in place, and the system did not function as it does on the Mainland. Records did show the EAS was activated at 8:34 p.m., December 7, announcing COR 1 would go into effect at midnight. Interviews with at least two television stations and one radio station indicated they did not receive the alert. Media representatives stated to the team, *“There are no procedures in place,”* and *“We are waiting for special equipment from Civil Defense in order to use EAS.”* Recent discussions with WFO Guam have confirmed funding for Homeland Security will allow the EAS system to be upgraded and an EAS Plan has now been signed. WFO Guam’s WCM is serving on a committee to help implement the new plan and EAS equipment. Edward Poppe, KSTO Radio (the EAS station on Guam), stated, he is *“excited. This is the first time in 8 years things have gone the right way. It’s the new administration.”*

## NOAA Weather Radio

NOAA Weather Radio (NWR), the voice of the National Weather Service, reaches all parts of Guam, as well as Rota and Saipan, through two transmitters. Normally, when watches and warnings are issued, the NWS transmits a signal alarming or turning on radio receivers with the proper technology. Specific Area Message Encoder (SAME) allows radio receivers to be programmed to turn on automatically or sound an alarm for designated geographic areas. At the request of Guam Civil Defense, the NWS does not use either capability except for tsunami warnings. **(Finding 9)**

The Guam transmitter has a backup generator serviced by U.S. Navy Public Works, an arrangement which has been unreliable. The Saipan transmitter has two diesel generators which are very old and serviced by a private company contracted by the Saipan Emergency Management Office. All NWR equipment is slated for replacement by the end of September 2003.



## **StormReady Program**

The NWS StormReady Program is successful in enhancing severe weather, tropical storm, flood, and tsunami preparedness. StormReady improves a community's ability to receive critical NWS products, fosters communication between the NWS and communities, and improves public response by supporting education efforts.

This was exemplified by what happened in Van Wert, Ohio, which became a StormReady community in January 2002. In Van Wert County, a communications system was established which allowed the rapid transmission of emergency weather information. On November 10, 2002, the manager of the Van Wert Cinema Complex used information from this communications system to direct 60 people to safety. The building was destroyed but no fatalities occurred. Had communities on Guam achieved StormReady certification, the 1 a.m. typhoon forecast change would have received more widespread dissemination.

The WFO Guam MIC established a StormReady Local Advisory Board toward the end of 2001. A detailed plan was created allowing for application by "any village or community" for StormReady recognition. Changes in the emergency management and civil defense administrations in the CNMI and on Guam, and the lack of a WCM at WFO Guam for seven months in 2002, resulted in the program remaining inactive. No applications were submitted. **(Finding 10)**

## **PEACESAT and High Frequency Radio**

The University of Guam relays weather information from the WFO using a public service satellite telecommunications network, Pan-Pacific Education and Communication Experiments by Satellite (PEACESAT). The university also transmits information via high frequency (HF) radio to small outer islands in the FSM. This is the only means of communication with some of these islands.

There is no operational HF radio transceiver and antenna installed at WFO Guam. An HF radio would provide a backup system, allowing WFO Guam to contact Weather Service Offices (WSOs) and smaller islands in the FSM, CNMI, the Republic of the Marshall Islands, and the Republic of Palau. The NWS is allocated four frequencies for use with this type of radio in the western North Pacific. **(Finding 11)**



Wreckage of a gas station along Route 4 in Agana, Guam. The Bank of Guam is in the background. (NOAA)



Downed utility pole along a back road east of the Bank of Guam (upper right) in Agana, Guam. (NOAA)

# Facts

## Executive Summary

**FACT:** Super Typhoon Pongsona was one of the worst typhoons to ever strike Guam. It resulted in one indirect death, 193 injuries, and over \$700 million in damage.

## Warning and Forecast Services

### WFO Guam

**FACT:** A lead forecaster, WCM, and SOO were off-island when Super Typhoon Pongsona struck Guam. The lead forecaster worked at the WFO Honolulu, Hawaii, during the event.

**FACT:** There was no designated lead forecaster assigned to forecast duties on the evening shift (4 p.m.-midnight) on December 7, 2002.

**FACT:** WFO Guam issued a typhoon watch for the island of Guam at 8 a.m., December 6. This was 47 hours before the onset of tropical storm force winds (39 mph).

**FACT:** WFO Guam issued a typhoon warning for the island of Guam at 8 a.m., December 7. This was 23 hours before the onset of tropical storm force winds (39 mph).

**FACT:** Wind measurements were available from only one anemometer on the northern half of the island during passage of the eyewall. This was the ASOS anemometer.

### WFO Honolulu, Hawaii

**FACT:** WFO Honolulu began partial backup by issuing aviation products at 4 p.m., December 8, took over all WFO Guam duties at 2 a.m., Monday, December 9, and ended its backup responsibility by 8:30 a.m., December 10.

**FACT:** WFO Guam and WFO Honolulu did not hold backup drills during 2002.

## **Joint Typhoon Warning Center**

- FACT:** The JTWC track forecasts for the three days leading up to Pongsona's passage across Guam were much better than JTWC's forecasts for all tropical cyclones for the period 1997-2001.
- FACT:** Pongsona made a direct hit on Guam which was not forecast.
- FACT:** While JTWC did forecast intensification of the storm, the trend was underestimated.

## **Partners and Customers Coordination**

### **Civil Defense/Emergency Management**

- FACT:** Guam Civil Defense is an active participant at WFO Guam workshops and coordination meetings.

### **Media**

- FACT:** WFO Guam has developed a strong working relationship with local media.
- FACT:** The primary local newspaper, the Pacific Daily News, from Friday, December 6, through Sunday, December 8, showed a map of the forecast track with Super Typhoon Pongsona passing to the east of Guam.

### **Public**

- FACT:** One theme stood out in assessment interviews with the public: people did not receive advanced warning of a storm of Pongsona's intensity.

## **Communications**

- FACT:** WFO Guam uses conventional facsimile as the principal product dissemination method.
- FACT:** During Pongsona, the WFO also provided updated information by cell phone and Internet.

## **Emergency Alert System**

**FACT:** During Pongsona, the Governor of Guam maintained control of the EAS. There was no signed EAS Plan in place, and the system did not function as it does on the Mainland.

**FACT:** Recent discussions with WFO Guam have confirmed funding for Homeland Security will allow the EAS system to be upgraded and an EAS Plan has now been signed.

## **NOAA Weather Radio**

**FACT:** WFO Guam does not use NWR SAME encoding or tone-alert on any products except tsunami warnings.



# Findings and Recommendations

## Warning and Forecast Services

### WFO Guam

**Finding 1:** A lead forecaster, WCM, and SOO were off-island as Super Typhoon Pongsona approached Guam, and were unable to return until after the storm passed. The WFO Guam office policy is unclear in detailing the number of senior staff permitted to be off-island at the same time.

**Recommendation 1:** WFO Guam should establish clear office policy detailing the number of senior staff permitted to be off-island at the same time.

**Finding 2:** The evening shift staffing on December 7 included three journeyman forecasters, an HMT, and the MIC. It was unclear to the assessment team who was the designated lead forecaster. Interviews revealed evening shift forecasters were concerned the forecast track was too far east. However, a call to JTWC was not made until the shift was almost over. The assessment team concluded a clearly designated lead forecaster on the Saturday, December 7, evening shift would have resulted in more proactive communication with JTWC and an earlier re-analysis of the forecast track.

**Recommendation 2:** WFO Guam should ensure every shift has a clearly designated lead forecaster.

**Finding 3:** Communication with WFO Honolulu, Guam's backup office, was limited to a satellite telephone that could not be used inside the WFO Guam building. Office staff actually went outside to call WFO Honolulu during the storm but didn't wait to receive calls.

**Recommendation 3:** WFO Guam should procure a satellite phone system, or modify the existing one, which can be used from inside the WFO building.

**Finding 4:** The four HANDAR instrument stations on Guam, which used sonic anemometers, all failed to report winds at the height of the storm. Wind measurements were available from only one anemometer on the northern half of the island during passage of the eyewall. This was the ASOS anemometer. However, data from this anemometer were not available due to the collapse of the tower that received radio transmissions from ASOS.

**Recommendation 4a:** Pacific Region should replace the four existing HANDAR sonic wind sensors with the sensors capable of providing accurate data in super typhoon wind and rain.

**Recommendation 4b:** Pacific Region should install a communication link between the Guam ASOS and the WFO capable of withstanding super typhoon force wind and rain.

## **WFO Honolulu, Hawaii**

**Finding 5:** Typhoon warnings for Alamagan and Agrihan Islands in the Marianas were cancelled 5 hours before the closest approach of Pongsona. In interviews with WFO Guam staff, some forecasters expressed concern warnings were cancelled too early. The Saipan emergency manager agreed. The two WFOs did not hold backup drills during 2002.

**Recommendation 5:** WFO Honolulu should review the portion of its SDM dealing with backup of WFO Guam. Particular attention should be paid to backup drills, staff profiles, and coordination of warnings.

## **JTWC**

**Finding 6:** JTWC track forecasts for Pongsona were better than average. However, a direct hit on Guam was not forecast and storm intensification was underestimated, resulting in below average service to the population. JTWC was reluctant to make a major change in the forecast track despite satellite imagery indicating the storm was moving farther west than forecast. Military forecasters at JTWC typically have less experience than civilian forecasters.

**Recommendation 6a:** The NWS should review JTWC service to WFO Guam, including staffing, techniques, and underlying science used by JTWC for typhoon forecasting in general, and for Super Typhoon Pongsona in particular. The review should determine why (a) the track was consistently too far east, (b) the magnitude of the change in intensity



was under forecast, and (c) there was a delay in updating forecasts to reflect the storm's actual movement.

**Recommendation 6b:** NWS should review existing agreements with JTWC concerning forecast responsibility in the western North Pacific and determine if modifications are needed.

## **Partners and Customers Coordination**

### **Civil Defense/Emergency Management**

**Finding 7:** The emergency response system on Guam is keyed to changes in COR levels and not to NWS tropical cyclone watches and warnings.

**Recommendation 7:** WFO Guam should work with appropriate Guam officials to resolve terminology differences between COR levels and watch/warning.

### **Public**

**Finding 8:** One theme stood out in assessment interviews with the public: people did not receive advanced warning of a storm of Pongsona's intensity. Several people referred to the expectation of a banana typhoon and not the intensity of a super typhoon. Tracking graphics published in the newspaper each day consistently placed the typhoon east of the island. Several people interviewed reported radio stations downplayed the strength of the typhoon (based on the forecast). There are no products which indicate the inherent uncertainty in track and intensity forecasts.

**Recommendation 8a:** The Pacific Region should request a graphical product from JTWC showing uncertainty in track and intensity forecasts.

**Recommendation 8b:** WFO Guam should stress forecast track uncertainty and its potential consequences in all public tropical cyclone products and should emphasize forecast uncertainty in outreach activities.

## **Communications**

### **NOAA Weather Radio**

**Finding 9:** WFO Guam does not use NWR SAME encoding and tone-alert for severe weather watches and warnings, including typhoon watches and warnings. The communications infrastructure on Guam is vulnerable to typhoon strikes. The primary communication methods used by the WFO to disseminate tropical cyclone products to users are easily disrupted.

**Recommendation 9:** WFO Guam should use NWR SAME encoding and tone-alert for typhoon watches and warnings.

### **StormReady Program**

**Finding 10:** The WFO Guam MIC established a StormReady Local Advisory Board toward the end of 2001. A detailed plan was created allowing for application by “any village or community” for StormReady recognition. Changes in the emergency management and civil defense administrations in the CNMI and on Guam, and the lack of a WCM at WFO Guam for seven months in 2002, resulted in the program remaining inactive, with no applications submitted.

**Recommendation 10:** WFO Guam should promote participation in StormReady throughout its area of responsibility.

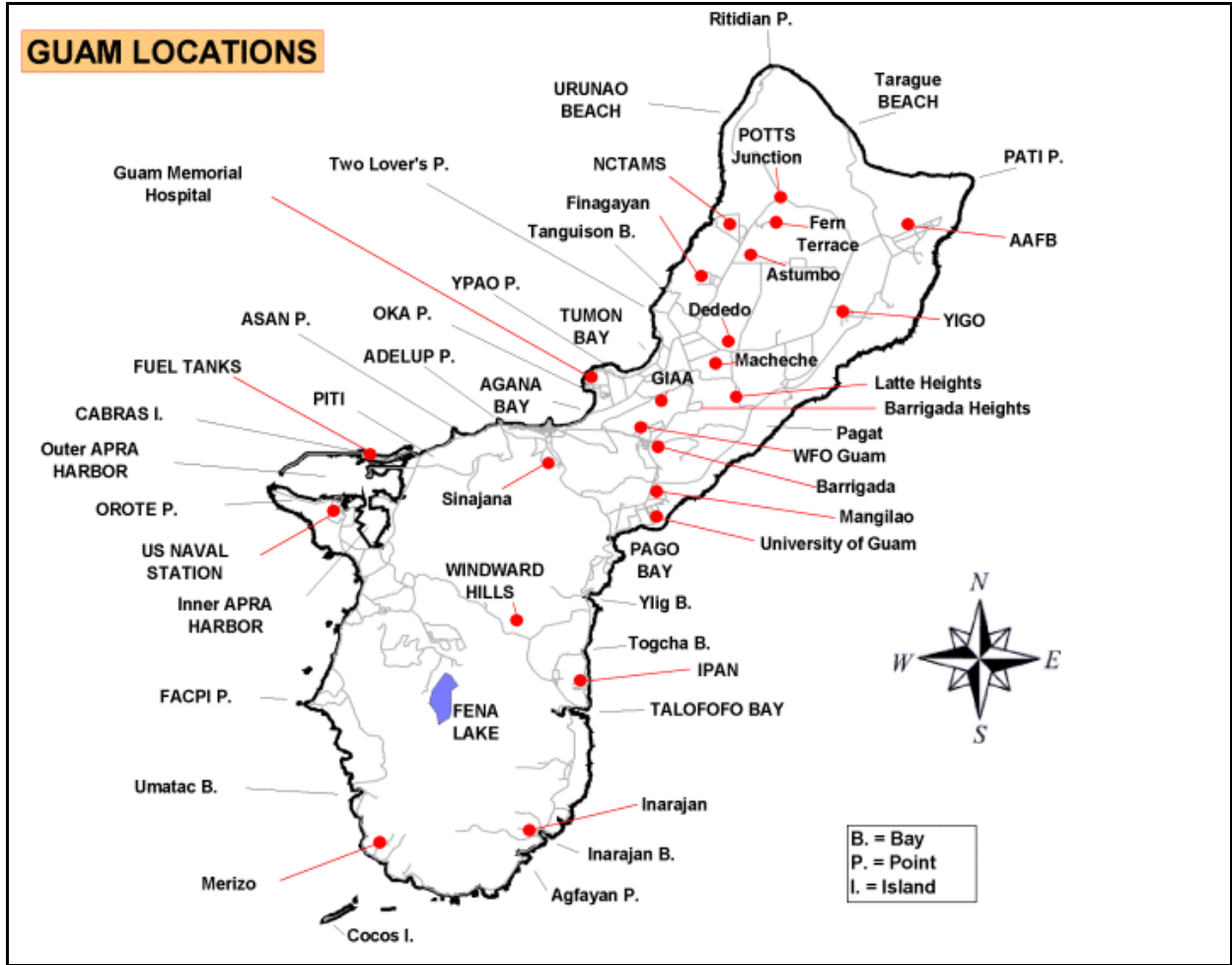
### **PEACESAT and High Frequency Radio**

**Finding 11:** There is no operational HF radio transceiver and antenna installed at WFO Guam. An HF radio would provide a backup system, allowing WFO Guam to contact WSOs and smaller islands in the FSM, CNMI, the Republic of the Marshall Islands, and the Republic of Palau.

**Recommendation 11:** The Pacific Region should install an HF radio transceiver and antenna system at WFO Guam capable of communicating with WSOs and smaller islands in WFO Guam’s area of responsibility. The system should be designed to operate during super typhoon conditions.

# Appendix A

## Guam Locations



## **Appendix B**

### **Conditions of Readiness (COR) for Guam, CNMI and Micronesia (Relationship of COR to Watches and Warnings)**

**1. Guam - The Navy, Air Force and GovGuam have agreed to standardize COR categories associated with tropical storms and typhoons. CORs are based on the timing of the forecast onset of 60 mph (50 kt) winds. They use either TS or TY CORs based on the forecast of the maximum intensity of the storm as it passes near Guam.**

**TS/TY COR 4 - normal conditions, winds of 60 mph (50 kt) or greater are possible within 72 hours.**

**TS/TY COR 3 - winds of 60 mph (50 kt) or greater are possible within 48 hours.**

**TS/TY COR 2 - winds of 60 mph (50 kt) or greater are anticipated within 24 hours.**

**TS/TY COR 1 - winds of 60 mph (50 kt) or greater are anticipated within 12 hours.**

**2. CNMI - The CNMI Government declares CORs for tropical storms and typhoons based on timing of the onset of damaging winds of 39 mph (34 kt) or more.**

**COR 4 - normal conditions, no threat identified, preparedness phase of operations.**

**TS/TY COR 3 - winds of 39 mph (34 kt) or greater are anticipated within 48 hours.**

**TS/TY COR 2 - winds of 39 mph (34 kt) or greater are anticipated within 24 hours.**

**TS/TY COR 1 - winds of 39 mph (34 kt) or greater are anticipated within 12 hours.**

**3. Micronesia - COR are based on the timing of the forecast onset of 39 mph (34 kt) winds. They use either TS CORs or TY CORs based on the forecast of expected winds. Micronesian islands are much more subject to damage from winds than Guam or Saipan.**

**COR 4 - normal conditions, no threat identified, preparedness phase of operations.**

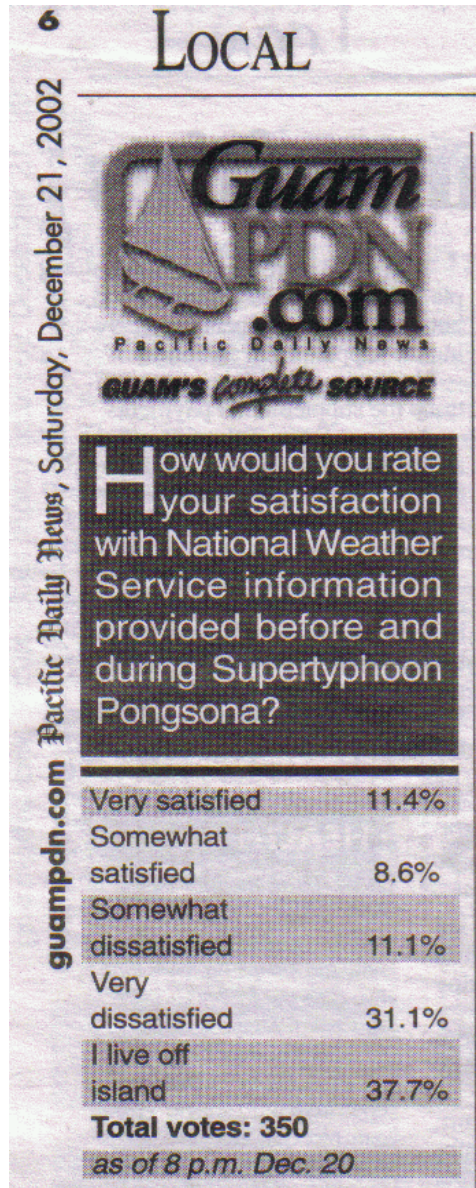
**TS/TY COR 3 - Tropical storm/typhoon conditions are possible within 48 hours.**

**TS/TY COR 2 - Tropical storm/typhoon conditions are expected within 24 hours.**

**TS/TY COR 1 - Tropical storm/typhoon conditions are expected within 12 hours.**

# Appendix C

## Pacific Daily News Survey



The results of a survey conducted December 20 and published December 21, 2002, by the Pacific Daily News, regarding reader satisfaction with the NWS forecasts before and during Pongsona. (© Pacific Daily News. Further reproduction is prohibited without the express permission of the Pacific Daily News)