PHILIPPINES TYPHOON WARNING SERVICE ASSESSMENT

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- EXECUTIVE SUMMARY -

This study's objective was to assess the current capabilities of the Philippine Government's typhoon warning service, the consequences of previous OFDA assistance, and an assessment on the progress of an OFDA funded Public Awareness Project. The information is based on a 10-day field visit (August 1988) to the Philippine Weather Service (PAGASA) headquarters in Quezon City.

PAGASA's typhoon detection and surveillance capabilities are largely based on satellite data bulletins from Japan. Its capability for forecasting typhoon future center location is about state-of-the-science for the 24-hr period

Currently, the Philippine typhoon warning system is capable of providing a useful, but limited, product for alerting coastal populations. A significant problem is communications and public response attitudes. The PAGASA warning needs to be creditable and understandable. Part of this can be accomplished by improved short term forecasts employing increased surveillance frequency. However, much of the improvement will depend on self-examination of revised methodology for timing, and content of the warnings, method of communicating these advices, and enhanced public awarness and education.

PAGASA's mainframe computer (VAX 11/730) installed under OFDA grant has operated sucessfully since the spring of 1985. In addition, the OFDA funded Natural Hazards Public Awareness Program (NHPAP) is off to a good start under strong capable management.

PAGASA will be experiencing many upgrades in its capabilities over the next several years. Equipment made available from Japan will enhance PAGASA's capacity for satellite reconnaissance of typhoons, as well as vastly improve its telecommunications and synoptic weather obsevation network.

Several recommendations are made for additional OFDA funding support in categories of developmental, and operational assistance which could increase the warning system's effectiveness in minimizing loss of life. Key among these are: 1) support for in-country surveys/studies, and follow-on workshop regards improvement in typhoon warning comprehension and utilization, and 2) acquisition of several microcomputers and peripherals to assist in communications transfer, forecaster aid product displays, bulletin preparation, and media protrayal.

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I. INTRODUCTION

In August 1988, The Office of U.S. Foreign Disaster Assistance (OFDA) retained Charles R. Holliday to perform an evaluation of the Philippine typhoon warning system. The review's objective and evaluation methodology are discussed below:

1. The study's objective was to assess the current capabilities of the Philippine Government's typhoon warning service and determine specific recommendations for possible OFDA assistance with other donors which could increase the warning system's effectiveness in minimizing loss of life.

2. The review was also to address consequences of previous OFDA assistance, and an assessment on the progress of an OFDA funded Public Awareness Project.

3. The evaluation methodology relied primarily on interviews and document reviews regards system operation and programs underway.

o A ten-day field visit was conducted in the Metro-Manila area to determine the workings of the Philippine Typhoon Warning System. No typhoons occurred during this period preventing the chance to witness and confirm operational actions in the warning system.

o Officials of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), The Univ of the Philippines (Dept of Meteorology), and US AID were interviewed to obtain technical and programmatic information.

o A listing of persons contacted appears in Appendix A.

II. BACKGROUND

The following provides a brief review of the typhoon problem in the Philippines, PAGASA's responsibilities and capabilities, as well as previous and current OFDA assistance to PAGASA.

1. Philippine Typhoon Problem

The Philippine archepeligo is in the main track corridor for western north Pacific typhoons and is subject to an average of four or more typhoon strikes per year. Usually the most severe of these systems affect regions of low population density (northeast coast of Luzon). However, during 1984 two intense typhoons (Ike and Agnes) striking the heavy populated areas in the Bicol, Visayas, and Mindanao, resulted in an approximated loss of life of 1800. More recently, typhoon Nina (Nov 87) caused the loss of life of 800 persons in the Bicol region. PAGASA regarded Typhoon Nina as responsible for the most significant damage to Philippine infrastructure (communications and transportation, etc.) of any previous typhoon. These losses, coupled with those in past typhoons, rank the Philippines first among tropical cyclone deaths suffered by any country in Pacific Asia during the decades of the 1970's and 1980's. Much of the root cause of this can be traced to the population vulnerability to storm surge (settlements along low lying areas of the coast, and weak housing materials), typhoon frequency threat, deficit communications, and response to warnings received.

2. PAGASA Warning Responsibility

Warnings are prepared when tropical cylcones develop or cross westward of 135 deg East longitude in the Philippine Sea (South of 25 deg North Latitude) and remain east of 115 deg East in the South China Sea. These advices are issued by the Weather Services Branch every six hours (5 AM, 11 AM etc). If the tropical cyclone poses a threat to the islands, Domestic Bulletins are prepared. Bulletins to shipping are issued as long as the storm remains within the Philippine Area of Responsibility. Flood forecasts are issued separately by the Flood Foreasting Office (at 10:30 AM, and 10:30 PM) if typhoons are affecting the major river basins of Agno, Bicol, Cagayan, and Pampanga of Luzon.

3. Detection and Surveillance Methods

With the loss of U.S. Air Force typhoon weather reconnaissance aircraft flights out of Guam and Clark Field (squadron closed September 1987), the primary surveillance tool for typhoons is the Japanese Geostationary Meteorological Satellite (GMS). The GMS stationed at 140 deg E on the equator provides infra-red images over the western Pacific and Asia region every three hours. Recently, hourly image receipt is possible for regions north of 10 deg north. For typhoons within range of land based radar, PAGASA maintains an early-warning radar network stationed along points in Luzon and the

Visayas (operational status of this network fluctuates considerably). Both land and ship weather observation coverage and frequency varies significantly during typhoon situations, adversely impacting sole reliance on this type of information for storm size, location, and intensity.

4. Forecast Capabilities

PAGASA center location prediction efforts are confined to the first 24-hr forecast period. These efforts rely primarily on subjective techniques utilizing forecaster skill and experience and empirical rules. Objective track forecast aids (primarily statistical) are available from output on the AID/OFDA provided VAX 11/730 computer. Forecast skill appears state-of-the-art with an average error of approximately 125nm. Unfortunately, uncertainity in initial position can cause large fluctuations from this average. Storm surge forecast capabilities are limited to subjective approaches and empirical rules.

5. Domestic Warning Bulletin

The bulletin delineates three levels of threat using a signal numbering system (combining time of arrival and intensity of winds) for designated geographical regions of the island archipelago. The highest level of threat is Signal three indicating onset of strong storm force winds (greater than 55 kts) within 12 hrs. Inclusion of the term "Big Waves" is made if a storm surge is thought possible with advice to move to higher ground.

6. Communications (Warning Dissemination)

Primary method of bulletin receipt among the population is over public radio. PAGASA weather service personnel pass the bulletin to wire service outlets, government offices, and television stations in metro-Manila. The bulletins are also relayed to PAGASA field stations for distribution to local radio stations and government officals via Single Side Band (SSB).

7. OFDA Assistance

o Typhoon Threat Assessment Program

In 1985 OFDA completed a nearly two year effort to upgrade PAGASA's typhoon early warning capability. This $500,000 "level of effort" activity entitled, "Typhoon Threat Assessment Program", provided state-of-the-science technology in typhoon forecasting plus hardware and software, and included training and technical assistance. Main components of program included: electronics maintenance training, and spare parts for PAGASA's Canadian built (McDonald Detwiller and Associates -MDA) GMS receiver, purchase, installation and training for operation of a Digital Equipment Company (DEC) VAX 11/730 computer with software to run U.S developed typhoon track prediction statistical techniques. Efforts also included a review of PAGASA's

bulletin message content and recommendations for enhancements to increase its effectiveness. Visits were arranged for several U.S. specialists with skills in various aspects of typhoon analysis and warning to provide on-site courses at PAGASA, and the Univ. of the Philippines.

o Natural Hazards Public Awareness Program

In May 1988, OFDA entered into another program with PAGASA for the dissemination of public information on natural hazards, with special emphasis on typhoons. The program's objective is to instruct threatened populations on the nature of the various disaster hazards (typhoon, flood, storm surge, land failure, earthquake, volcanic activity, etc.) and provide critical information on preparedness and mitigation to save lives. The program will be heavily focused on both community and school children awareness. Phase one of the project will cost $100,000 over 18 months and a second phase, if approved, will expand the pilot activity as a national program at an additional estimated cost of $165,000.

III. CAPABILITIES - PAGASA TYPHOON WARNING SERVICE

I. Detection/Surveillance

The current status of PAGASA's storm detection and surveillance capabilities is marginal. The Japanese GMS image receiving and displaying facility is operating in the low resolution mode only (not of reconnaissance quality). Only two weather surveillance radars of a network of eight are working. A circuit outgage to Clark field since January has resulted in non-availability of U.S. Air Force satellite typhoon surveillance message bulletins. With the loss of U.S. Air Force aircraft reconnaissnce capability (since Sept 1987), PAGASA depends almost entirely on Japanese satellite typhoon surveillance bulletins from Tokyo.

o GMS Satellite Receiver

The Canadian built high resolution satellite receiving facility has been inoperative since May 86. Circuit boards that had been identified as defective were sent to the MDA factory for replacement/repair. However, upon return they still failed to function. The Murihead hard copy display device is inoperative as well. Image examination is restriced to a low resolution signal received at the PAGASA weather service forecast office. The facsimile machine is capable of providing a crude image with two shades of gray.

The situation stands a chance for great improvement with the addition of a Japanese built workstation by the end of the year. This item is discussed under the Donor Assistance section. Capabilities of this workstation need to be assessed later to see if system improvements as well as data interpretation training are needed. PAGASA typhoon analysts do not currently have the training necessary to take full advantage of the system's storm surveillance capabilities.

o Japanese Satellite Message Bulletins

PAGASA receives coded message bulletins from Tokyo (Japanese Meteorological Agency - JMA) regards the location and intensity of tropical storms/typhoons every six hours (Japanese GMS). Information is not provided on tropical depressions, and intensity estimates are crude due to shortcomings in the code.

o U.S. Air Force Satellite Message Bulletins

U.S. coded and plain language message bulletins are based on analysis of both U.S. NOAA and Air Force high resolution polar orbiting satellite data as provided by the Air Force sites in Guam, Clark Field, and Kadena Air Base, Okinawa. Analysis of Japanese GMS data is performed at Guam furnishing additional information. Location and intensity information is provided for all levels of tropical cyclone intensity. The intensity analysis information is more refined

then that provided in the JMA satellite bulletin messages.

This data is not received at PAGASA due to a circuit outage with Clark Field since January. The problem is discussed under the communication (incoming) section.

o PAGASA Land Based Radar Network

The PAGASA radar network consists of eight sites (Aparri, Basco, Bagluo, Baler, Daet, Virac, Guluan, Mactan, and Busuanga) a ninth site is near completion near Tanay (just east of Manila). Almost all are Raytheon built WSR-77 models (Bagluo - WSR-57, Aparri - Japanese built). Of these only two are currently working (Bagulo and Daet). Basco is inoperative due antenna damage suffered in typhoon last year (blown down). The station near Aparri suffered fire damage, and is planned to be built nearer the town. Key early warning radars at Virac, and Guiuan are out of commission. Both these and the rest of the radar installations suffer maintenance problems, spare parts and generator diesel fuel shortages - a chronic problem with the network. (A radar-site network map appears in Fig 1)

Further complicating the issue is the absence of experienced on-site electronic technicians. Those that are experienced and trained are difficult to keep since many leave for Saudi Arabia or other countries in Southeast Asia with higher pay scales. Currently PAGASA has four technicians at its headquarters that are dispatched to the field to repair the installations. Many of these sites do not have easy access by commerical air which further complicates matters.

PAGASA has overextended itself in developing such a large radar network. It would be best if the network was reduced to a level of a few maintainable stations in strategic locations (proximity to vulnerable population regions), for nowcasting purposes (short term forecasts), and leave the gaps to be filled by satellite imagery surveillance.

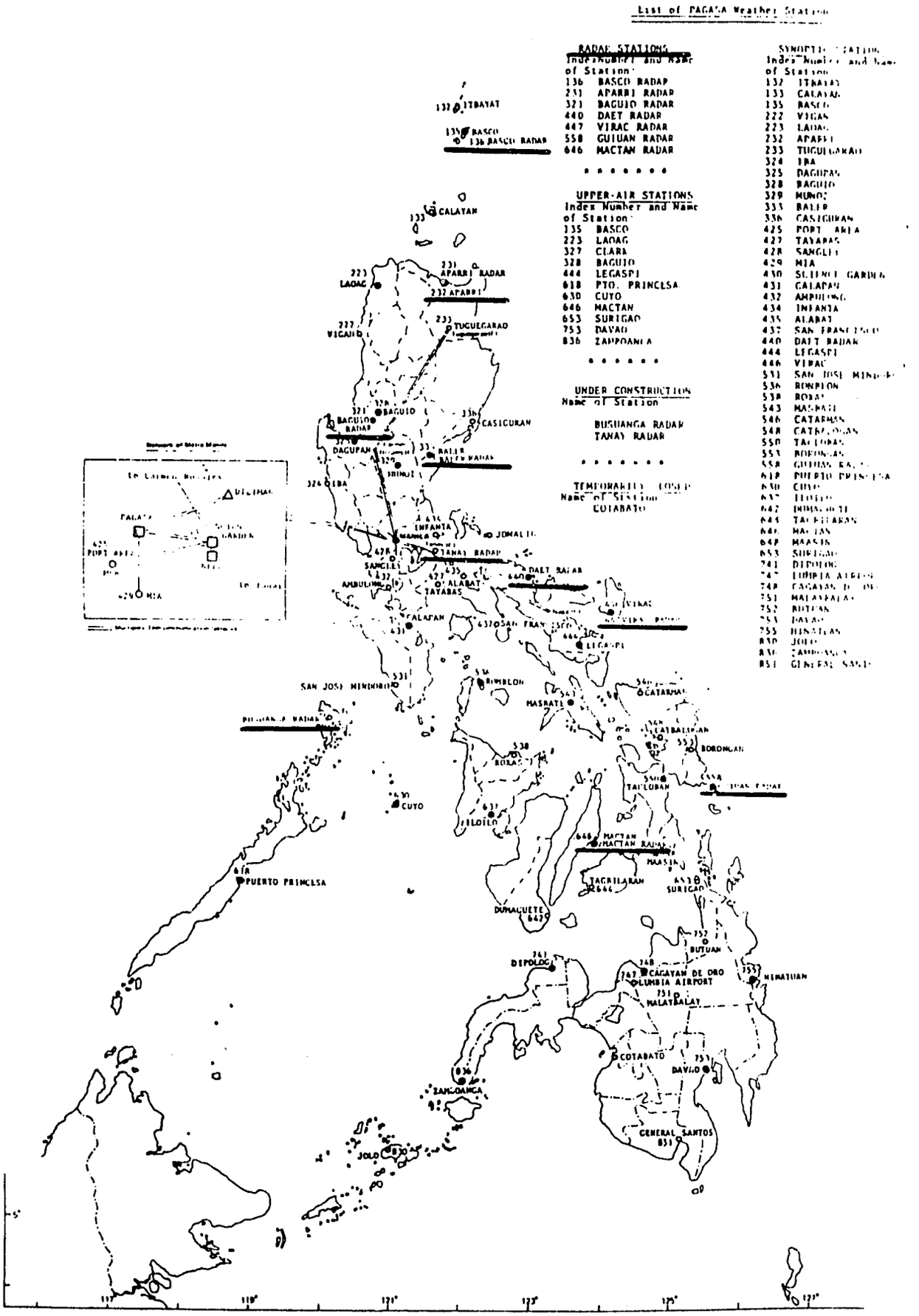
Both the U.S. Navy/Air Force benefit from timely early-warning typhoon surveillance from these radars. It might be worthwhile to check the feasibility of DOD airlift assistance for PAGASA maintenance personnel, spare parts and other critical supplies to key inoperative sites prior to a possible typhoon threat (case by case basis)

o Surface Observation Synoptic Network

When a typhoon is in its weaker stages it is more difficult to locate either with satellite imagery or radar. Surface observations from PAGASA's land station prove critical to chart these type storms. Unfortunately, the network is hampered with inoperative equipment (wind and pressure instrumentation), and sometimes ineffective telecommunications for timely notification of weather conditions at the field sites. In many cases, forecasters have difficulty tracking storms through the island archipelago.

This condition may be remedied in the future as Japan plans to

PAGASA WEATHER STATION'S LOCATION



rehabilitate some of the synoptic network (including spare parts) as part of its major telecommunication upgrade for the 1990's (discussed under Donor Assistance section). (France also has tentative plans for assistance in instrumentation replacement.)

2. Communications (Incoming)

PAGASA receives data through the World Meteorological Organization (WMO) Global Telecommunications System (GTS) with links to the hubs at Singapore (75 bps) and Tokyo (200 bps). Weather data received in-country is principally by Single Side Band (SSB). SSB broadcast (HF-7995 KHz) is subject to interference between sunset and sunrise greatly degrading the reliability of reception for observations between 12 GMT (8 PM) and 21 GMT (5 AM).

Almost all radar sites are equipped with Low Freqency (3650 KHz) radio transceivers which are not as susceptable to interference as the SSB. However, PAGASA's central office doesn't have the roof space large enough to house an antenna. It appears this capability can't be exploited till the office moves to their new building (Data Information Center (DIC) - see p15).

Until this past winter, PAGASA has had a drop on a high-speed U.S. Air Force weather data link between Hickam AFB and Clark field. This has been a principal source of information for U.S. typhoon satellite bulletin messages as well the typhoon forecasts from Guam. (The Tokyo circuit relays the Guam warnings usually 30 min later).

The drop on the Hickam to Clark circuit has been out of commission since January with significant loss of valuable data. PAGASA has been linked to the circuit through JUSMAG (Joint U.S. Military Assistance Group), however no signal is being received at JUSMAG now. Mr. Fontano (OIC/ Telecommunications Section) states that problem appears to be located in relay from Villamor Air Base (Philippine Air Force - PAF) near Manila International Airport (MIA) and the Airport Transportation Authority Office (ATO). He said that he would purchase a cable to link the data between Villamor and PAGASA's airport office. Data will be screened and entered manually on the teletype circuit between the airport office and the forecast section at Quezon City). Mr. Fontano stated the cable would be installed before next year.

This patch work effort doesn't present a reasonable long term solution however. A communication computer will be necessary to ensure automation of this effort and effective transfer of high speed data to the Quezon City Office.

Mr. Fontano indicted that with addition of a special cable and teleprinter to handle the high speed (1200 bps) Hickam to Clark line, the data would be equal to that furnished over both the Tokyo and Singapore lines. Savings in lease charges would amount to about $48,000 annually.

3. Analysis and Forecasting

No tropical cyclone entered the Philippine Area of Responsibility during my visit. The following discussion on analysis and forecasting is without benefit of viewing the system in action.

PAGASA center location prediction efforts are for the 24-hr period only, no routine effort is made to prepare or verify forecasts for longer periods. (A 36-hr outlook position is made available if Manila is threatened on the weekends). Forecasters appear to continue to rely primarily on subjective techniques utilizing forecaster skill, experience and empirical rules based on current data with emphasis on 24-hr surface pressure changes and hourly station observation sequence charts. Evidence of objective (statistical) technique (run on the VAX 11/730) exploitation couldn't be established during the visit

Forecasters could probably benefit from availablity of upper atmospheric field (10,000 ft and above) analysis and prediction charts based on global numerical models. Review of these charts may be of assistance to establish track recurvature potential on a dynamic basis. Such charts are available by radio facsimile from both Guam and Japan. PAGASA doesn't currently have such equipment. (Equipment specifications are listed in Appendix D.)

Forecasts from the Joint Typhoon Warning Center, Guam with predictions out to the 72-hr period are available over the Tokyo circuit. However, the latest warnings arrive too late for review before PAGASA issues its international and domestic bulletins. The Guam six-hr old warning is available if necessary, but this is probably used more for the initial position information than for the forecast value.

PAGASA 24-hr forecast skill on the average falls in the category of state-of the-art (125 nm). The problem of initial position and intensity uncertainty leading to extrapolation efforts ,however, can often result in individual cases significantly deviating from the average. PAGASA's capability at nowcasting (short term) is crippled by lack of operational radars and a functional high resolution satellite imagery display

A 36-hr position forecast outlook would probably be of great value to government, and disaster preparedness officals. Although within the technical feasibility of PAGASA, there is no thought of attempting such an effort

4. Storm Surge Forecasting

The largest loss of life in a typhoon strike is associated with the storm surge. Currently, no quantified storm surge prediction technique is available. Efforts to recognize storm surge possibilities (yes/no only, no magnitudes) are focused in Signal three areas (coastal regions expected to receive 55 kt winds or greater) and reference to empirical rules and statistical methods. Adapting a

surge model for operational real-time forecasting to a given region requires laborious data acquisition. The bathymetry of water areas, and surface topography of land must be specified for each model grid square. The Univ of the Philippines (Dept of Meteorology/Oceanography) is interested in developing the data base necessary for a operational storm surge model provided funding assistance is achieved. The data base would be digitized from maps supplied by Government's Coast and Geodetic Survey into a computer data base for subsequent run on the University's model. The model could be run on PAGASA's VAX 11/730 or a microcomputer (discussion with Dept. Chairman).

5. Warning Dissemination

The primary means by which warnings reach the public is the radio. The following describes the method in which PAGASA relays the information.

Forecast office personnel read the warning over the phone to a predetermined group within the metro-Manila area. These include government offices (Office of Civil Defense, and others), the wire services, Voice of the Philippines, newspapers and television. Success in delivering these bulletins vary, particularly on the weekends. Forecast office personnel also broadcast the bulletin over station DZCA (government station) for recroadcast. The station's low power (5kw) limits its range to metro-Manila.

Communications Section personnel prepare the Bulletin for international transmission via teletype and internally via single side band (SSB). SSB is normally monitored in the field every three hours (GMT plus every 3 hrs), and the Warning is broadcast at these intervals. The main shortcoming with SSB broadcast is the interference encountered between sunset and sunrise greatly reducing chances for reception between 12 GMT (8 PM) and 21 GMT (5 AM). Field Offices are often not able to receive the 11 PM bulletin at all.

Personnel also relay bulletins directly to Governors, Mayors in the threatened provinces via Bureau of Telecommucications (telegraph). This process is being changed over to telex via Philippine Telephone and Telegraph Company. Both systems are hampered by the fact that field offices are closed on weekends and open only from 8 AM to 5 PM daily.

PAGASA field offices will contact local radio stations (phone or hand carry) and pass the bulletin message. In some cases, the individual will be hooked in live on the air and read the bulletin themselves. (In most cases these persons are not meteorologists but sub-professionals (observers)) In addition, field personnel will notify key local government officals (this is often quite difficult on the weekends).

Office of Civil Defense uses SSB to relay bulletins to its field offices for dissemination to the local media and officials. Using HF

they experience the same interference problems. Greatly lacking in the communication system is a reliable hard copy transmission capability which is not susceptible to interference. Installation of the Japanese funded multiplex telecommunication system for PAGASA should solve this problem in the 1990's.

6. Media Protrayal

Mr. Pinea - Weather Services Information officer does a live evening broadcast six days a week at the channel 7 news center in Quezon City. This metro-Manila broadcast is carried to other provinces of Luzon by relay. The medium for protraying the weather or typhoon threat is particularly cumbersome. A large map of the Philippines is used with weather features depicted which are grossly out of scale giving a false impression of the threat, and developing misconceptions among the public. A low resolution satellite image with extremely poor contrast (two shades of gray) is also featured.

The poor quality satellite picture issue should be solved once the Japanese GMS workstation is installed with hard copy capability late this year. The graphics display of the typhoon threat (path, warning areas, size of storm, etc) could use a significant upgrade. A desktop microcomputer with graphics software and hardcopy capacity would aid the flexibility of presentation considerably. The graphics display copies could be formatted quickly for release to other TV stations and newspapers.

7 Bulletin Message Content

The structure and content of the domestic warning bulletins has remained unchanged since the 1984 OFDA analysis. Review of bulletins for selected landfalling typhoons during 1987 and 88 reveals the following:

Absence of any distinquishing level of warning for the dangerous typhoon (maximum winds in excess of 100 kt). The current highest level of threat (signal three) delineates for only winds equal or greater than 55 kt. Discussion with Mr. Parong (OIC/forecasting section) indicates a reluctance of adding a additional signal level without a public education effort first. He cited a Weather Services Branch staff meeting last year which surfaced concern for confusion among the public of an additional signal. Initatives for implementing a public information are needed.

Last year an attempt at comparative analysis in the warning bulletins for Typhoon Nina (November) apparently backfired. The bulletins stated that the typhoon was on a track similar to that of Betty (August) which traversed the Bicol region. Betty, however, took a more southerly path through the region and did not affect the towns north of Legaspi significantly. The Nina post storm survey through this region revealed that residents thought that Nina wouldn't be much of a problem, and were surprised at its fury with a direct strike.

Overwarning is also a problem. The signal one and two levels (winds up to 30 kt within 36 hrs, and 30 to 50 kt within 24 hrs respectively) cover a significant area that could be reduced. The current procedure has lead to significant loss of credibilty. Revision to how these signals are employed or possible redefinition should be considered.

Technical terms in the domestic bulletin such as wind speeds which are expressed in units of km per hour are abstract subjects to the user community in the countryside. Categories of strength based on potential damage such as a ranking of one through five or such would be more useful. Example:
....Category 5 (200 km/hr.....shrubs and coconut trees blown down; all signs down. Extensive damage to roofing materials. Major damage to structures near shore due to flooding and battering by waves and floating debris, etc.....
Caterories similar to this have been developed by L. Amadore when he was with the Typhoon Moderation and Research Development Branch (TMRDB), and were referenced in the 1985 OFDA report on message content. Implementation of such categories in the domestic bulletin would improve user comprehension.

Hard evidence and testimony from the user community might convince the Weather Services Branch that some changes are needed in its domestic bulletin messages. Several programs are underway, or being considered, which can contribute to the knowledge base necessary for intiating changes. Programs underway include Part I of OFDA's NHPAP under direction of Ms Garcia which is ideally positioned to contribute. Ms Garcia is already conducting baseline research on the knowledge, attitudes, and reactions of those affected by natural hazards including the typhoon. Work at the TMRDB continues to build a data base for Amadore's wind damage categories through post storm damage surveys. Among programs being considered are specific interview surveys (topic - utility of current warning messages) in vulnerable populated areas most recently affected by devastating typhoons.

8. OFDA Sponsored Workshop.

A workshop in which results of the above surveys and studies could be presented would be an ideal forum to discuss findings, and finalize needed revisions in warning messages Such a workshop could also bring together the necessary liaison between provider and user of the warnings regards the issue of protrayal and communications of the typhoon threat. Participants would include members of PAGASA's weather services branch, the TMRDB, damage survey team members, OFDA's NHPAP players, together with user community representatives from vulnerable typhoon regions - such as the Bicol . The workshop's objective would focus on recommendations to improve comprehension and utilization of the warning message. The group would screen these recommendations for operational utility. A final set would be agreed upon for incorporation into the message preparation operating

procedures and, where applicable, included in the educational material to be distrubuted in Part II of OFDA's NHPAP.

It is recommended that OFDA sponsor the survey program being considered, and the follow-on workshop with Ms Garcia acting as coordinator of the effort. Her current envolvement and managment skill in conducting OFDA'S NHPAP, and familiarity with designing and conducting field workshops would ensure a productive forum. The workshop should be targeted for early 1990 - time enough for necessary planning, and preparation of the workshop, as well as time available for any intergration of recommendations into the educational materials of OFDA's Part II NHPAP before they are finalized.

IV. MAIN FRAME COMPUTER (OFDA Grant)

The Digital Equipment Corporation (DEC) VAX 11/730 Computer supplied through a OFDA grant has functioned without significant failure since it became operational in March 1985. Components of the system are listed in Appendix B.

1. System Development

Mr Monroy (OIC/Development Section) has looked after the system as if it was his own. He has been quite creative in its utilization including a wiring to the outside telecommunication section for ingest of operational real time data via the Tokyo circuit. The Tokyo link permits access to automated fields produced by the European Center for Mid-Range Forecasting (ECMRF) at Bracknell, England. Mr. Monroy has installed a floating point accelerator (used module) which greatly speeds up computation time. He has also programmed a crude graphics display (geographic - coastline/lat-long) and line drawing function to depict typhoon tracks for output on line printer(slow process)

Mr. Monroy has a staff of four programmers. Two of them have attended a special course in data processing in Singapore entitled "Software Development for an Automated Meteorological Processing Center" The other two programmers are receiving on-the-job training.

2. System Applications

Primary useage of the system has been for development work (testing numerical analysis and prediction models, various forecast aids). Fourteen objective (primarily statistical) typhoon prediction aids are in the data base including strike probabilities. These are run every six hours when a typhoon threatens, and are produced in tablular form (printout using Mr. Monroy's graphics display is also possible).

The current employment of the objective techniques is to lump them together for an average value. This has several drawbacks when the individual techniques are not screened for performance in verification. Several of the techniques (statistical-synoptic) such as the Arakawa, Veigas-Miller and Feraspar continue to underperform and should be removed. The Kalman Filter (which objectively determines the current position from various reconnaissance platforms) is being erroneously employed as a forecast aid, and given equal weight with the other tools (even though it shows one of the worst verification scores). I discussed this matter with Mr. Monroy, and Ms Sodusta (author of the verification study). I recommended several revisions be made on employment of these objective aids.

3. System Operation

The computer is shut down when not in use. When tropical cyclones form or enter PAGASA's warning area, the computer is manned by at least one individual around the clock (three shifts). The system has a voltage regulator system to handle the freqent commerical power

outgages. However, all data in working memory is lost during these periods. There is no Uninterrupted Power Supply (UPS) for backup. The computer is shut down by one of the duty operators to prevent damage from a power surge. This system will be moved (with the rest of the forecast office) to the Data Information Center (DIC) two miles away when the Japanese funded building is completed (1991). The DIC will have a UPS for backup.

3. Improvements Needed

The system's graphics display capability is crude and slow with only a line printer available. A desktop microcomputer with color graphics enchancement and software packages hooked-in to the VAX system could rapidly protray the display needed on screen output, and provide hard copy with screen dump to a laser printer. The microcomputer could run programs independent of the mainframe as well, and be used as word processer for typhoon warning bulletin text.

The processing speed of the system deteriorates rapidly with each user load. Without memory upgrade, any attempt to put in additional peripherals without compensating increase of physical memory slows down the system for efficent operation. An upgrade of physical memory (memory chips/circuit board) from 1 Megabyte (MB) to 5 MB would greatly alleviate this problem.

V. DONOR NATION ASSISTANCE

PAGASA will be receiving considerable assistance from the Japanese over the next several years in terms of satellite imagery receipt and display, a Data Information Center building, and installation of a advanced telecommunication network. Both France and Australia are either beginning or finishing feasibility studies for assistance to PAGASA. These programs are discussed below. (A planning schedule summary is listed in Table 1.)

1. Japan Assistance

o GMS workstation

The Japanese will be installing a basic workstation (Nippon Electric Company) to receive, process, and display high resolution satellite imagery from the Japanese GMS. This equipment will be financed through a loan from the Japanese Overseas Economic Cooperation Fund (OECF). Estimated cost is $400,000. Equipment will be installed at the PAGASA's Typhoon Moderation and Research/Development (TMRD) building. This is the current site of the GMS antenna (Canadian-MDA) and is located off Quezon Memorial Circle some 2 miles from PAGASA's central office. Factory training (hardware and software) for two PAGASA engineers is currently underway in Japan. The workstation should be operational by the end of the year.

o Data Information Center (DIC)

As part of a follow-on program supporting an interagency effort (PAGASA, with the National Irrigation Authority, and National Power Corporation), the Japanese will be constructing a Data Information Center (DIC) building (to house components of the Flood Forecasting Network) next to the TMRD building. The DIC is included as part of larger effort including a rainfall telementry network and warning system for two Dams (Ambuklao and Magat). The OCEF loan for the entire system is $30 million. The DIC will provide new quarters for the Weather Service and Flood Forecast branches including telecommunications and computer facilities. The DIC will feature an Uninterrupted Power Supply (UPS) to combat the fluctuations of commerical power. Forecast date for occupancy is 1991.

o Telecommunication Network

The OCEF has approved a $10 million loan for construction of meteorological telecommunication system connecting PAGASA's 64 weather stations throughout the country. This system will be comprised of both data transmission and telephone channels which can also be used for facsimile transmission. The network will consist of a main trunk system using multiplex radio link, data collection, and relay stations. Branch circuits composed of VHF and HF bands will be

directly connected with the data collection and relay stations. A dual-formatted computer system will be installed at the DIC to control the telecommunications of data acquisition, dissemination and to both edit and compile data. Relay stations on the main trunk will be provided with stand-by generators in case of commerical power interruption. Project will include training for both operation and maintenance.

The Program will be implemented in two stages:

Stage 1: Construction of system in Luzon Region
Stage 2: Construction in Visayas and Mindanao region.

Following completion of engineering system design by late 1989, construction will begin on the network by mid-1990. Completion is targeted for mid-1995.

2. French Assistance

France is considering a loan of $4.7 million to support a PAGASA initiative of estabishing a regional forecast center (enhancing meteorological service to the countryside). PAGASA's top priority is Naga with subsequent interests in Cebu, Tuguegarao, and Cagayan de Oro. The effort would include upgrading the existing weather office into a forecast center with satellite and facsimile receivers (linked by the existing flood forecasting microwave relay network). The regional forecast office would serve as service delivery office to the countryside. Direct connection of provincial broadcast stations with these regional forecast offices will facilitate faster typhoon warning and weather forecasts. Establishment of a broadcast station at the office is under study.

Also considered under the proposed program is the establishment of several automatic data collection platforms, and the rehabiliation of basic weather instrumention equipment for 10 principal and 10 secondary surface observation stations (including spare parts and consumables).

A team of French contractors (Sofreavia, Paris) will conduct a feasibility study in 1989 for an implemention plan.

3. Australian Assistance

The Australian International Development Assistance Bureau (AIDAB) is planning a loan (ceiling $7 million) for a project beginning in 1989 to improve the availibility of information for resources planning and management through more extensive applications of remote sensing technology. Much of the effort is focused on the National Mapping and Resources Information Authority (NAMRIA), and the College of Engineering Training Center, Univ. of the Philippines. Some project components provide assistance to PAGASA. These include the following:

o Design and installation at NAMRIA (Fort Bonifico) of an antenna for reception of high resolution (HR) data ($300,000) from the U.S. NOAA (polar orbiting satellites).

o Installation of a display and analysis workstation at PAGASA ($130,000) for interpretation of HR data received from NAMRIA.

o Installation of telemetry equipment for transmitting the data to PAGASA ($20,000).

o training in maintenance and equipment operation, and data interpretation ($30.000).

Projected completion data is 1990. Data analysis from this equipment could be of assistance in typhoon surveillance; however, its frequency (twice a day) and area of coverage is less desirable then that provided by the Japanese GMS. The operational reliability of data transfer might be in question since NAMRIA would have control. NAMRIA does not operate under a 24-hr, 7 days-a-week schedule.

TABLE 1 - DONOR NATION PROJECT IMPLEMENTATION PLAN

I. ..... Near to Mid-Range ....

	1988	1989	1990	1991
-JAPAN-				
o GMS Workstation	X			
o Data Information Center Bldg		O ----------		X
o Telecomm Network				
-Luzon Region			O --------	
-Visayas/Mindanao				O
-AUSTRALIA-				
o NOAA Workstation PAGASA/NAMRIA		O ----	X	
-FRANCE-				
o Regional Forecast Center		S		

II. ..... Far Range .....

	1992	1993	1994	1995
-JAPAN-				
o Telecomm Network				
- Luzon Region	----------		X	
- Visayas/Mindanao	----------			X

Legend : O - Start
X - Completion
S - Feasibility Study

VI. TYPHOON MODERATION AND RESEARCH DEVELOPMENT BRANCH (TMRDB)

The TMRDB has several initatives underway which are of interest in the disaster preparedness and response arena. The first is development of a typhoon damage assessment model, another is an evaluation of a survey on public response to typhoon warnings. Both depend on the TMRDB VAX 11/750 main-frame computer (PAGASA funded) for data processing. A third area of effort includes surveys of typhoon damage.

1. Wind Damage Model

The wind damage model is in an infant stage with many preliminaries to be worked out before it can get off the ground. The model addresses a symmetric typhoon wind field currently. To be useful for disaster planners an asymmetric wind field needs to be developed incorporting topographical effects. A data base incorporating agricultural and housing type distribution and their susceptability to various wind magnitudes is needed. A data base for topography will also need to be developed. Resources do not appear to be available to make significant advances with this model. Models such as this have been prepared in the U.S. for coastal and other regions.

2. Warning Response Survey

A initial survey on human response to typhoon warnings (conducted in 1984), is being analyzed and is 90% complete. However, its scope is somewhat limited. Members of the TMRDB staff felt that a more thorough and better designed survey is needed. Interviewers need to be better trained, and more communities in different regions need to be sampled. In addition, more time should be allowed for conducting the field program.

3. Typhoon Nina (Sisang) Damage Survey (Nov 87)

The TMRDB is among several of PAGASA's components which participate in post damage surveys. Other members include representatives from the Information Office (Office of the Director), and the Geophysical Branch. Much of their task is to document the exact path of the storm, determine storm surge height, and both extent and type of agricultural and housing structural damage. A non-scientific collection of public response attitudes is a by-product of these surveys.

In typhoon Nina 800 people were reported killed ranking the storm as the third highest killer in PAGASA records since WW II. At the town of Bacon, north of Sorsogon (in the Bicol), over 200 people drowned in the accompanying storm surge. A town further up the coast north of Legaspi - TIWI- also experienced a storm surge which swept some 300 houses away from the shore line, yet there was no report of loss of life.

The survey team interviews revealed that the efforts of a volunteer worker for the Social Welfare and Development Department in TIWI (Ms Bella Boral) can be largely credited for saving these lives. Upon hearing that "Big Waves" were forecast in the signal three area which TIWI was included, Ms Boral organized a group to warn the coastal residents, and evacuate the area. Ms Boral acted upon her previous disaster preparedness training concerning typhoons and the consequences of the accompanying storm surge. In the case of Bacon, the warning was largely ignored; no community leader took action. (a copy of tha survey team's report is attached for reference - Appendix D)

This contrast in community response is a stark example of benefits in disaster prepardness training. (Ms Garcia said she will likely incorporate this real life tale in her educational materials for the OFDA Public Awareness Program). A copy of Ms Boral's report "Sisang got Mad" is attached for reference (Appendix D.)

The survey team videotaped discussions with several residents of both communities as well as damage scenes. An edited version of this tape was presented at a Workshop for the First National Convention on Disaster Management held this past May in Los Banos, Laguna. I had a copy of this tape made, and it is now on file at OFDA.

This PAGASA survey team travels by ground vehicle (or boat) and receives no assistance from other Government agencies (Philippine Air Force, Coconut Federation, etc) for air hops, aerial survey etc. The data this group collects is invaluable for verification and follow-on assessments. Access to some areas is difficult following a storm, and travel to and from the area is signifcantly time consuming. Direct aerial surveys as well as airlift to an area would greatly enhance the geographical coverage of the survey. Assistance from the U.S. military might be of great value.

VII. NATURAL HAZARDS PUBLIC AWARENESS PROGRAM

The OFDA funded Natural Hazards Public Awarness program under direction of Lolita Garcia (Office of the Director) is progressing well. Aspects of the Pilot Program for Grade School Curriculum Development, and Community Awareness Baseline Research are discussed below.

1. Grade School Curriculum Development

Workshops for curriculum development on disaster preparedness and prevention in the grade school have been completed in all 5 regions of the Pilot Program (workshops conducted July to mid-August). These 3-day workshops held at elementry schools or regional education centers (metro-Manila held at PAGASA) consisted of a dozen or more grade school teachers, science supervisers, and curriculum writers representing various districts of the region. Lectures on natural hazards were given by a PAGASA representative (TMRDB or Geophysical branch). Under the coordinating guidelines of Ms Garcia, the teachers determined the scope of lessons on the subject and its mitigation. Their task was to determine the deficiencies of the current school program, and what improvements can be made. Attendees were committed, and enthusiastic in their workshop participation.

2. Community Awareness Baseline Research

Under the Community Awareness Baseline Research effort, the data gathering phase just got underway toward the end of my stay. PAGASA teams were leaving for both the Bicol and Moro Gulf region at that time. This effort, using PAGASA interviewers, will cover several communities in each of the 5 regions under the Pilot study. The interview techniques employ a Focused Group Discussion method including in-depth interviews of both a cross section of the general community as well as it leaders (8 persons from each group). This research focuses on the group's knowledge, attitude, and practices regards natural hazard mitigation; their educational levels; language, media preferences; and media availability in areas of the program implementation.

I discussed the interview material content with Ms Garcia in view of PAGASA typhoon warning bulletin message interpretation and lead time. In this context, I recommended several additions in the purposed question outline. These suggestions were incorporated in the interview structure.

3. Follow-on Efforts

Next Phase of the Pilot Project will include:

- Development and Pre-testing of Information Packages for Grade School Cirrculum
- Development of Disaster Preparedness Program
- Preparation of training design

4. Project Director

The project is in good hands, Ms Garcia (a seismologist by trade) is well organizied and a thorough planner. Her management methods (people and material) have resulted in a good start for the project. She is an enthusiastic, and pragmatic individual who believes in field work, interacting with people, understanding their perspectives of the problem. It is evident that she produces a very favorable impression on those who come in contact with her in the provinces.

VIII. SUMMARY AND RECOMMENDATIONS

1. Summary:

The Philippine typhoon warning system is capable of providing a useful, but limited, product for alerting coastal populations. A significant problem is communications and public response attitudes. The PAGASA warning needs to be creditable and understandable. Part of this can be accomplished by improved short term forecasts employing increased surveillance frequency. However, much of the improvement will depend on self-examination of revised methodology for timing, and content of the warnings, method of communicating these advices, and enchanced public awareness and education.

PAGASA is dependent on satellite data from Japan to keep abreast of the formation, development and advance of typhoons in the western Pacific region. Its capability for forecasting the future center location is about state-of-art for the 24-hr period on the average. Storm surge prediction capabilities could be greatly improved.

U.S. aircraft typhoon reconnaissance is no longer available, thus poorly defined typhoons and weaker tropical storms (not easily positioned in satellite data) present a problem which can easily result in adverse impacts on location of 12 and 24-hr forecasts.

The PAGASA communication network based on Single Side Band radio provides an unrellable method of transfer of data and warnings.

The public receives the warnings primarily through commerical radio, however, response is often fragmented due to the varied reaction to the bulletins. This area requires considerable attention so improvements can be made in public warning methods, as well as promoting hazards awareness to provoke appropriate public response.

The main frame computer (VAX 11/730) installed under OFDA grant has operated sucessfully since the spring of 1985. The computer has enhanced PAGASA's capabilities in processing operational real time weather data, generating objective statistical typhoon forecasts, and providing testing of developmental dynamic models.

The OFDA funded Natural Hazards Public Awareness Program is off to a good start under strong capable managment. Results from this effort will have far-reaching potential for promoting approriate public response when typhoons threaten.

PAGASA will be experiencing many upgrades in its capabilities over the next several years. Equipment made available from Japan will enhance PAGASA's capacity for satellite reconnaissance of typhoons, as well as vastly improve its telecommunications and synoptic weather observation networks. Both France and Australia are also developing feasibility plans for assistance.

2. Recommendations:

OFDA's main support efforts should focus on enhancing aspects of public disaster preparedness and education. At the same time, support funding assistance should be extended for efforts which have a clear potential for enhancing surveillance, forecasting, and communications for typhoon early warning not addressed by other donor nations.

Suggested areas for OFDA support consideration are listed below in categories of developmental, and operational, and coordination assistance. Reference page of item discussion is cited. Funding estimates, and suggested implementation time period are included.

A. Developmental:

o Support surveys, studies, and follow-on workshop: Subject - improvement of Typhoon Warning Message Comprehension and Utilization (p 11/12).
Cost ..$50,000 - FY 1989-1990 in Manila

o Support development of data base grid for Univ of Philippines Storm Surge Model(p 8/9)
Cost ..$30,000 over 3 yrs - FY 1989-1991.

B. Operational:

o Support acquisition of two microcomputers for graphics display and hard copy (p 10 and 11).
(IBM Series 2 model 80 or equivalent with laser printers and associated software)
Cost ..$15,000 per package/$30,000 total - FY 1989-1990).

o Fund communications microcomputer and upgrade teleprinter for access to high speed Hickam-Clark line via link from PAGASA's airport office to Quezon City (p 7).
(IBM XT model with associated software and AN-UGC141 teleprinter or equivalent)
Cost ..$10,000 - FY 1989-1990)

o Support acquisition of radio facsimile equipment (p 8).
(Alden model 0315R recorder with antenna, fax scanner and spare parts or equivalent.
Cost ..$10,000 - FY 1989-1990).

o Evaluate capabilities of Japanese Satellite workstation for possible improvements, and assess need for interpretation training (p 5)
Cost ..$10,000 - FY 1989-1990

o Upgrade working memory on VAX-11/730 from 1 MB to 5 MB (p 14). (memory chips/circuit board)
Cost ..$3,000 - FY 1989-1990)

C. Coordination Assistance (U.S. AID/Military in-country)

o Airlift assistance to ensure operational readiness of strategic radar sites (p 6)

o Airlift assistance for damage surveys (p 20)

APPENDIX A
PERSONS CONTACTED

Listed below by organization are principal persons contacted in the Philippines.

1. US AID MISSION

   - o Malcom Butler - Director
   - o Bryant George - Regional Development/ Disaster Relief Officer

2. PAGASA

   Office of the Director

   - o Roman Kintanar - Director
   - o Juanito Lirios - Deputy Director /Operations and Services
   - o Cipriano Ferrais - Deputy Director /Research and Development

   Weather Services Branch

   - o Mariano Asuncion - Chief
   - o Eduardo Parong - OIC /Forecasting Section
   - o Sixto Fontano - OIC /Telecommunications Section
   - o Gambriel Monroy - OIC /Techniques Development Section
   - o Auado Pineda - Information Officer
   - o Anita Sodusta-Staff Meteorologist

   Typhoon Moderation Research and Development Branch

   - o Crisitomo Reyes - Chief
   - o Kim Adung - Assistant Chief
   - o Jamie Bucoy - OIC /Research Section
   - o Rhaphel Lao - OIC /Computer Operations

   Atmospheric, Geophysical, and Space Sciences Branch

   - o Catalino Arafiles - Chief
   - o Rolu Encaracion - Staff Geophysicist
   - o Lolita Garcia - Staff Geophysicist (assigned /Office of the Director)

   Flood Forecasting Branch

   - o Leonico Amadore - Chief

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Field Operations Center

- o Gemelo Galang - Acting Chief
- o Stanley Agojo - Staff Engineer

Engineering and Maintenance Division

- o Deogracias Caro Jr - Chief
- o Ricardo Guevara Jr - OIC /Meteorological Equipment Section

3. UNIVERSITY OF THE PHILIPPINES

o Dr. Jorge de las Alas - Chairman, Dept of Meteorology and Oceanography

4. NASA TEAM FROM GODDARD SPACE FLIGHT CENTER (GSFC)
(Period of visit to Metro-Manila 10 to 15 Aug)

- o Fran Stetina - Systems Manager, Ocean Data Systems Office /GSFC
- o Dr. John Hill - Associate Director, Remote Sensing and Image Processing Laboratory /Louisiana State Univ.

II. Listed below are principal persons contacted at the Office of Foreign Disaster Assistance (OFDA) in Oct 88 during briefing of preliminary findings.

- o Fred Cole - Assistant Director, Asia Pacific Div
- o Ray Dionne - Disaster Operations Officer
- o Paul Krumpe - Technical Advisor

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APPENDIX B

- VAX 11/730 System Components -

. VAX 11/730 CPU

. Operating System ---
  - . RL02-F
  - . R80-AE
  - . MS730-CA
  - . DMF32-AA

. VT100-WA - Video Display Terminal
. VT101-AA - Video Display Terminal
. LA100 - Printer Terminal with Keypad
. LA100 - Printer Terminal without Keypad
. TU80 - Magnetic Tape Drive

System Cost	- $59,754
Installation and Maintenance (1 yr)	- $17,659
Total	- $77,413

Note: Regular Price	$79,000
Less Special Discount	$19,246
NET	$59,754

(Data from PAGASA files (Mr. Monroy's Unit): dated 13 Jan 1986)

APPENDIX D

MISC ATTACHMENTS

1. Typhoon Nina damage survey report.
2. "Sisang (Nina) got Mad" (Bella Boral's report)
3. Alden radio facsimile equipment discription.
4. Communications outage - PAGASA drop on Clark Field to Hickam AFB high speed weather data circuit (Mr Fontano's report).