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RECONNAISSANCE REPORT: FLOODING RESULTING FROM TYPHOON URING IN ORMOC CITY, LEYTE PROVINCE, THE PHILIPPINES

by

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Typhoon Uring passed over the Island of Leyte on 5 November 1991 on an east to west track north of Tacloban City and Ormoc City. The center of the typhoon was at the midpoint of the Island about 10:00 a.m. and took 3 to 4 hr to pass across the Island width. Widespread damage from flooding was left in its wake. The Coastal Plain from Ormoc City at the north to Baybay at the south situated at the western side of the Island received major damages. The Ormoc watershed and Ormoc City were the hardest hit areas.

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PREFACE

This work described in this report was authorized by Headquarters, US Army Corps of Engineers (HQUSACE) under agreement with US Department of State, Office of US Agency for International Development (USAID), based on a request for assistance from the Philippine Government Development of Public Works and Highways.

This report was prepared by Dr. Monte L. Pearson of Geotechnical Laboratory (GL), US Army Engineer Waterways Experiment Station (WES) and Mr. John G. Oliver, Chief, Hydraulics and Civil Design Branch, North Pacific Division.

Site guidance and logistical assistance were provided by Messrs. John Starnes, USAID/Philippines and Pacifico G. Mendoza, Jr., Regional Director, Department of Public Works and Highways, Government of the Philippines, and staff member.

The work was conducted under the general supervision of Dr. William F. Marcuson, Director, GL; MAJ General Harrel Ernest, Jr., Commander, Messrs. Robert Flanagan, Chief, Planning and Engineering, and Edward Daugherty, Chief, Technical Engineering Branch.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

EXECUTIVE SUMMARY

Typhoon Uring passed over the Island of Leyte on 5 November 1991 on an east to west track north of Tacloban City and Ormoc City. The center of the typhoon was at the midpoint of the Island about 10:00 a.m. and took 3 to 4 hours to pass across the Island width. Widespread damage from flooding was left in its wake. The Coastal Plain from Ormoc City at the north to Baybay at the south situated at the western side of the Island received major damages. The Ormoc watershed and Ormoc City were the hardest hit areas.

The storm speed and the accompanying intense rainfall were the main causes of the damages. Because of the storm's speed on the eastern slope of the mountain range, low elevation runoff passed through the Coastal Plain before higher elevation runoff was routed to the coastline. Conversely, on the westside the higher elevation runoff arrived at the coast about the same time that lower elevation runoff was most intense.

Rainfall intensities were extremely high with 140.2 mm recorded at Tacloban City in 3 hours, 580.5 mm and 350.0 mm recorded in 36 hours at PNOC Raingage 1 and 2. The major portion of the rain at PNOC is reported to have occurred in 3 hours. Extremely intense rainfall was also reported to have occurred at Ormoc City in a 3-hour period.

Soils in the region were totally saturated a short time after inception of intense precipitation. Soil strengths were decreased and significant surface failure occurred to a depth of about 1 to 3 m in the upper basin. Stream bank and bed erosion was also intense. Bulking of flows by sediments contributed to the magnitude of the flood. It is also likely that the upper river basins both east and west experienced debris flows that at lower elevation dropped to intense sediment transport leaving the larger boulders but continuing to carry woody debris and up to gravel size material that was capable of damming bridge sections.

Streams in the region are well incised, and side slopes have limited stability. Evidence of high sediment transport prevail throughout the systems. Stream lower reaches are braided at low flow and have numerous channels. Stream bed slopes are high, estimated to exceed 1 percent within 200 m of their mouths and average 5 to 7 percent throughout their lengths on the western slopes. Under those circumstances, stream orientation under various flows is difficult to predict. Deep erosion around hardened surfaces, bank protection, bridge piers, abutments, and contractions are normal. Large fluctuations in river bed elevations are common as sediment pulses pass through reaches.

The intense flood at Ormoc City which lies just below the confluence of the Antilao River and Malbasag River was caused by extremely intense rainfall and upper basin soil instability. The major loss of life at Ormoc City occurred just upstream of the main City, in the Isla Verde area. Flood plain zoning may have assisted in reducing the losses experienced.

Factors that could reduce future localized flooding and infrastructure damage are improved approach alignments of the streams with bridges, reduction of stream contraction, and raising of bridge decks to prevent damming of bridge section with debris. Based on the 5 November 1991 flood event and a future risk analysis, bridge redesign criteria development throughout the system should give consideration to river alignment, existing river widths and the latent instabilities associated with high velocity major sediment and debris transporting systems.

The following is a list of recommendations.

1. Provide zoning to prevent habitation in high risk areas.
2. Provide flood warning systems where practicable.
3. Establish the frequency and size of the event so both risk and the economic impact of remedial measures can be analyzed.
4. Improve design criteria for infrastructure.
5. Stabilize slide surfaces to minimize sediment mobilization during minor events
6. Provide stream improvement and diversions.

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RECONNAISSANCE REPORT: FLOODING RESULTING FROM TYPHOON URING IN ORMOC CITY, LEYTE PROVINCE, THE PHILIPPINES

Background

The Philippines is an archipelago of 7,107 islands and stretches from the south of China to the northern tip of Borneo. Total population is about 60 million. Leyte is one of the major islands and lies at about 11° 15' N latitude (Map 1).

Leyte Province is located on the Island of Leyte in the Republic of the Philippines. The island is 350+ km south southeast of the capitol city of Manila. Typhoon Uring moved onto the island early Tuesday morning on 5 November. Although storm winds were relatively weak, packing sustained winds of only 55 kph, it unleashed heavy rains over Leyte beginning on 4 November on a Monday night. The rains became extremely intense Tuesday morning. Landslides in the mountains were triggered and vast parts of lower elevation areas of western slopes were flooded by mud and water by noon Tuesday.

The flooding is considered to be the worst to have occurred in the Philippines in 7 years. Up to 3 m of soil laden floodwater submerged Ormoc City and outlying towns. Coastal area residents were caught without warning. The death toll was extensive with most being drowned or buried in mud as their houses were swept away. The city of Ormoc with a population of 150,000 was hardest hit with approximately 4,800 dead and 1,857 missing.

Bridges along the western coastline received severe damage. In total, 16 bridges were damaged or destroyed. Most of this occurred between the cities of Ormoc and Baybay. Early estimates of property damage have been P 395M. Agricultural crops, poultry, and livestock accounted for P 35M, infrastructure, P 130M and private properties, and public facilities accounting for the remaining P 230M. Power failure was widespread as power poles were destroyed.

Mission

On 12 November 1991, Headquarters, US Army Corps of Engineers was contacted by the Department of State regarding Corps assistance on determining the cause of the flooding and possible mitigation measures. Two engineers with extensive experience in river morphology were dispatched to the Philippines on 4 December 1991. The team was comprised of Mr. John G. Oliver, Chief, the Hydraulics and Civil Design Branch, North Pacific Division, and Dr. Monte L. Pearson, Senior Research Scientist, Geotechnical Laboratory, US Army Engineer Waterways Experiment Station.

The team spent 5 December through 13 December 1991 in the country. Meetings were held with the US Agency for International Development, and primarily with the Philippine Government Department of Public Works and Highways. The basic requesting letter, complete listing of contacts, and basic trip itinerary are included in Appendix A.

Geologic Setting

The Island of Leyte was formed by volcanic action consisting of strata volcanoes, dome complexes, pyroclastic/tephra cones calderas and compound volcanoes (Philvocs Annual Report 1988). The volcanic core complex is concentrated on the north central portion of the island. The central areas are classified as "volcanic terrain."

The Philippine Fault System is the major tectonic feature of the region. The system trends NW-SE through Leyte with all of the volcanic cones resting on the eastern block of the Philippine Fault. The intense tectonic activity has highly sheared and fractured all geologic formations on Leyte.

The basement geology of Leyte is pretertiary igneous and metamorphic rocks traversing the length (North-South Axis) of Leyte. Fluvial marine and terrace gravel deposits of early Neogne-Latte Preleogene overlay the basement complex. Pleo-Pleistocene volcanic formation of andesitic composition is the youngest exposed formation within the area. The flanks of the volcanic complex are blanketed by pyroclastic materials mainly of Lahar origin. The Lahar deposits in the watershed area are typical poorly sorted (boulder-pebble-gravel sized andesitic clusts) and matrix (sand size). The lowlands are fluvial sediments of unconsolidated matrix gravel type.

The soils in the Ormoc watershed have been classified by the Philippine Bureau of Soils as "upland soils." They are characterized by undefined soil horizon with great erosion potential. Soils are formed originally from decomposed andesitic rocks. These are granular and noncohesive, unstable and highly susceptible to erosion and transport. The upper watershed has steep slopes, and a high rate of soil formation due to rapid decay of andesitic rock materials and climatic factors. In order to maintain slope equilibrium an equal volume of soil mass removal and reformation occur (regolith). The numerous fresh slide in Bao, Malitbog, and the other drainage included in the Ormoc watershed support this data. High rainfall rates serve as a catalyst which triggers the majority of the shallow mass movements. The Department of Science and Technology (Department of Science and Technology 1991) also supports this finding, and it states that the average soil profile is 7 m thick.

Drainage System

The Regional Disaster Coordinating Council of Region 8 (Regional Disaster Coordinating Council 1991) provides a complete description of the Ormoc watershed. Ormoc watershed is composed of three major subdrainage basins. This report will only describe the northwestern two drainage. They are the two major systems directly associated with the 5 November 1991 flooding of Ormoc City.

The Antilao and Malbasag Rivers are the two major drainage systems that directly impacted Ormoc City. These two rivers converge upstream of Ormoc City and the Isla Verde Area (Map 2).

The Antilao River drains the northernmost portion of the watershed and is composed of three subbasins (Map 3). The middle portion of the watershed is drained by the Malbasag River and only has one subbasin. The Malbasag River is the smallest of the two in area and channel length, 10.8 km compared to 16.3 km for the Antilao drainage (Figures 1 and 2). The total drainage length of the two systems is approximately 27.0 km.

Drainage in the Ormoc watershed is dendritic in pattern and well incised. Upper channel incisions are characterized by a 1/3-width/depth ratio based on a ridge/stream measuring system. Progressing downstream the width/depth ratio just upstream of Ormoc City is about 3 to 1.

The Antilao River has a vertical drop of 84.5 m in 13.2 km on the mainstem for an average of 6.4 percent slope, whereas, the Malbasag River has a slope of 6.2 percent. The average fall of both streams is 64.8 m/km. All the streams in the Ormoc watershed flow southwest and converge above or near

Ormoc City (Map 2) The confluence of the two rivers is 2.5 km from the Camotes Sea. The junction is about 5 m above average sea level (ASL). The mainstem is 13 to 15 km in length and drains approximately 190 km^2.

Data gathered during field reconnaissance indicate that mass movements were shallow failures ranging from 1 to 3 m in depth (Photos 1 and 2) and 50 to 100 wide at head failure zone. Movement generally occurred from ridge line to the channel bottom. The soil mass in the upper watershed has been classified as cohesionless media which failed at a ratio of length/depth to shear plane of 10 to 100. Photos 1 and 2 provide positive illustration of this relation.

In a dry state these cohesionless soils rely upon interparticle frictional strength for stability. Upon wetting, the interparticle frictional strength is reduced, and as total saturation occurs, the strength factor is reduced to 0 at which time failure occurs. Further, the highly weathered and relatively thick soil masses have developed internal shear planes. Subjected to intense rainfall, the shear planes become failure planes. The short and high intensity rainfall in these circumstances created mass movement features that were long and shallow. Combining all the data, surface soil mass with internal shear planes, stream side slopes exceeding 60 percent, and cohesionless soil, it is apparent that during wet conditions the slopes in the upper 2/3 of the Ormoc watershed are highly unstable.

Channel Morphology

For descriptive purposes the Ormoc drainage basin has been divided into three basic valleyway-channel geometries (upper, middle, and lower) that are directly related to the geomorphology of the region (both slope and channel processes).

The upper basin area represents the areas of highest topographic relief drainage and are the headwaters for the basins. Down-drainage out of channel topography has slopes up to 30 percent. Side slope in the valleyway channels are up to 60 percent. According to Land Resource Evaluation Report (LRER) Leyte Province (Bureau of Soils and Water Management 1986), this area constitutes 20 percent of the watershed area. Channelways are deeply incised with near vertical channel walls up to 10 m above the channel bed (Figures 2-3 and 9-10). Large historical mass movement scars are visible with recent (5 Nov 91) small failure scar superimposed. The dates of historic failures are unknown, but dating could be used to aid in establishing flow frequencies.

The width/depth ratio normally related to change geometry has been modified to represent channelway and channel area. The channelway is the deeply incised area with the active channel (braided) in the basin area. The upper basin area width/depth ratio is nearly 1 to 3. This portion of the watershed has experienced the highest percentage of mass movement events. The majority and most recent are shallow failure features which normally ran out to the channel area at the base of the slope. Material delivered by this process is saturated. Upon delivery to the stream, materials are immediately entrained and the total flow is bulked by the added sediment. Flow bulking by sediments was a significant phenomena during the 5 November 1991 storm in the higher and steep channel slope areas. The sediment-laden water was transported down the deep, narrow and generally straight channel system to the Middle Basin Area (Photo 3).

The Middle Basin Area terrain has slopes of 18 to 30 percent and represent about 18 percent of the total basin (Bureau of Soils and Water Management 1986). The width/depth ratio changes to approximately 2 to 3 and the channel side slopes are still steep at 60 percent (Figures 4-5 and 11-12). Again, shallow mass movement features are prevalent along the channel valleyway. Sediment loading and bulking processes were similar to that in the upper basin area. With the increase in discharge, bed degradation and bank erosion processes produced additional sediment to the system. The channel in plan view at the low flow is more meandering and braided. At higher flow this meandering and braided form undoubtedly disappears.

The lower basin area (excluding Ormoc City and the Delta Area) is still well incised with a width/depth ratio of about 3 to 2. Meandering and channel braiding are the major low flow plan form features. Down-drainage slopes are reduced to 8 to 18 percent.

The mainstream of the Antilao and Malbasag Rivers, as stated earlier, are incised and highly meandering in this reach (Figures 6-8 and 12-13). The meanders induce a high degree of channel sinuosity, which create deposition zones upstream of each meander bend (Photo 3). Momentum loss and backwater effect results in deposition of the boulder/gravel material in transport.

Loss in momentum, produced by the sharp direction change, reduces stream power which reduces transport capacity. Once the flow has exited, the meander stream power is regained, and bend, bed, and bank erosion/scour occurs. This sedimentation/erosion process repeats itself through the lower reach. With each repetition the D_{50} size of material transported is reduced. This process explains the lack of a large volume of boulder to gravel size sediments within the flood effected area of Ormoc City. The gravels and finer fractions did continue down the system and deposited in the city and Camotes Sea. Significant amount of woody debris was also transported and may have formed up as part of a debris flow at the front of the flood (Photo 4).

Ormoc City and Delta Area

The Ormoc City/Delta Reach can be considered the delta/beach reach of the system. Town development and cultural features have fixed the channel location. The junction of Antilao and Malbasag Rivers just upstream of Ormoc City creates a single major river through town. The channel width/depth ratio through town appears to be 3 to 1; however, the incision and width are not natural. The channel geometry has been adjusted and the reach is smaller than those of the lower basin areas. The reduction in flow area and adjustment of slope associated with the delta are contributing factors which resulted in massive out-of-channel flow in the Ormoc City area. Photos 5 and 6 show that at the Antilao Bridge (km 1010+968.2) a 90° direction change occurred. The momentum change combined with the contraction should have had the severe effect of putting initial flow overbank at this location. Along with debris flow and woody material impacting this area, the bridge was eventually removed. Flood water entered the Ormoc City street system to a depth of 3 to 5 feet, creating significant property damage. The recent lobate deposit at the mouth of the system suggests that the coarse fraction of sediment continued to transport in the channel and through the town to Ormoc Bay. The Isla Verde area upstream of the Antilao Bridge was flooded several feet above overbank, and residents living within the floodplain were decimated (Photo 6).

Ormoc City is located at the lowest elevation on the coastal delta of the Antilao and Malbasag Rivers. Both drainage join about 2.5 km from the coastline and 1 km north of Ormoc City Proper. At the confluence point the drainage is wide. Significant residential development within riverbank lines and on banklines between Ormoc and the confluence point had occurred prior to the flood.

Highway No. 302 channelizes the drainage system to the northside of the highway. The emplacement of Antilao River Bridge induces a 90° channel bend. At the bridge site the channel changes from 300± m wide by 3 to 4 m deep to 30 to 40 m wide and 10 m deep. The change continues from the river bridge through Ormoc City to the bay. The constriction greatly increases the flood potential immediately upstream and through the City (Photos 4, 5, and 6, Map 2).

Upstream of the Antilao River Bridge in the Isla Verde area (Map 2 and Photo 5) is a zone composed of a colluvial sediment of gravel and sand size. The material is representative of the deposition area of steep braided gravel channels. As stated earlier, this section of the floodplain was densely inhabited. Based on information provided by the Ormoc City Engineer, there were a variety of dwelling types; none able to withstand a significant flow event.

A third drainage system (Biten River) flows just to the east and south of Ormoc City Proper. The extent of flooding or impact on the Antilao and Malbasag Rivers flooding of Ormoc City was not determined but could have been a factor.

Meteorological Conditions

Tropical Storm Uring developed on 2 November 1991 and continued until 6 November 1991. Uring was a relatively small and weak storm system. Uring maintained typhoon status for less than 24 hours starting about 1000 hours on 5 November 1991, while located some 350 km east of the region. The storm tracked east to west across Leyte passing north of the Ormoc City Area. After crossing Leyte, Uring weakened to a tropical depression and on 6 November 1991 at 10:00 am, tropical depression Uring dissipated to a low pressure system (Map 4).

As the storm system advanced on Leyte, intense rainfall started about 0730 hours on 5 November 1991 at Tacloban City (Map 4). Rainfall records at the Tacloban Airport indicated 140.2 mm of rainfall in a 24-hour period with the most intense cccurring in only 3 hours, 0730 to 1030 hours.

Intense rainfall began about 0830 hours at the PNOC rain gages 1+2 (Map 3). At about 1130 hours the highest rainfall intensity had decreased or stopped according to PNOC officials. Uring was traveling at 12 kph as it moved across the Island. Based on travel speed and distance, intense rainfall should have started in Ormoc City at about 0930 hours on 5 November 1991. As per conversations with city officials, intense rainfall did occur approximately 0930 hours on 5 November 1991. Rainfall intensity and winds were of a high magnitude; areas of extensive blowdown occurred. Photo 7 shows an area of blowdown in the upper drainage section of the watershed.

Rainfall records (Table 1) from November 1976 to 1991 for the VISCA weather station located 8 km north of Baybay, Leyte provides a general indication of rainfall quantities for the coast areas period of record. Baybay is located 30 km south from Ormoc City and some 850 m lower in elevation than the upper portions of the Ormoc watershed. Based on meteorological principles, it is possible to extrapolate that rainfall amounts in the upper watershed areas could commonly be one or two orders higher in magnitude. The VISCA station reported 238.4 mm in 24 hours compared to PNOC Rain gage No. 2 of 580.3 mm (the PNOC Hostel and nearest to Ormoc watershed, Map 3). This rain gage is located at an elevation of 435 m above sea level which is only 2/3 up the drainage basin in relative elevation.

The Flood

At Ormoc City the flood waters flowed out of the lower basin into the Isle Verde area entraining buildings and most other items in its path. It is probable that a front wall of woody material and debris reached the bridge and restricted flow through the Ormoc City channel. The bridge restricted channel width and 90° bend created some backwater effect almost instantaneously. Channel width at the available slope was inadequate to contain the flow within banks. The stage hydrograph of the event as described by local residents and partially recorded on video tape is as shown in Figure 14. The water surface rose by 7 feet in 15 minutes, and an hour after flow peaked, the hydrograph was falling. The total flood lasted less than 4 hours. Flow in the streets of Ormoc City as recorded on video tape had a depth of 3 to 5 feet. Average sediment depth was described as 2 feet deep after the flood waters had receded. Sediments in the streets were fine grained and characteristic of suspended load. Materials offshore of the river mouth appeared to have a much greater fraction of coarse material, and it is believed that most of coarse material passed through the river channel as near bed suspended load. Sediment transport and flow should then be governed by principles used for Newtonian fluid.

The Special Task Group Regional Disaster Coordinating Council, Region 8, used the rainfall record of 580 mm at Tongonan, PNOC Rain gage No. 2 which is nearer and more proximate to the Ormoc Watershed and assumed that 80 mm of the precipitation occurred between 10 p.m. on 4 November to 8 a.m. on 5 November 1991. Based on that assumption, 500 mm was the rainfall from 8 a.m. to 11 a.m. on 5 November 1991. The total volume of water that flooded Ormoc City was:

watershed area x rainfall
4,500 hectares x 500 mm or
45,000 sq m x 0.5m
Q = 22,500,000 cu m of water

We estimate that about an equal amount of sediment was transported. Assuming a 35 percent porosity in sediments, the total volume of fluid was about 37,000,000 cu m. To estimate the peak flow rate and to get further insight into flood potential at Ormoc City, a preliminary routing was done on the flood. The basin was broken into 6 areas with 500 mm of rainfall introduced into areas 3, 4, and 5 uniformly between 0800 and 1100 hours on 5 November and in areas 1, 2, and 6 between 0900 and 1200 hours (Map 5). Sediments were introduced in run No. 1 Figure 15a at 0800 hours and in run No. 2 Figure 15b at 0820 hours. Sediment was only introduced in areas 3, 4, and 5. Sediment introduction was in proportion to rainfall. The flood peak at Ormoc City was at 1050 hours for run No. 1 and at 1120 hours with a 10-minute shift in initial sediment input on run No. 2. Peak flows were between 70,000 cubic feet per second and 80,000 cubic feet per second, channel capacity through the City is estimated to be much less than 30,000 cubic feet per second. The receding side of the hydrograph on both runs is extremely sharp which is the result of the assumptions on where sediment was introduced and upon rainfall intensities.

An inspection of the routings indicates that the slope of the rising leg of the routed hydrograph is too flat, and it is likely that a debris flow was at the front of the actual flood. The debris flow would have retarded the arrival time of the peak because of increased viscosity and friction. It would also have increased the peak flow. The receding side of the hydrography is too steep, based on the local description of the stage hydrograph. Lower elevation sediment entrainment was significant and was not introduced into the simulation, and some ponding occurred in the Isla Verde area. Therefore, a gentler slope would be expected if more realistic assumptions were made.

From the limited analysis, it is evident that the sediment event accompanying the rainfall had a significant influence. Detailed analysis of the hydraulic conditions at Ormoc City could be used to confirm and adjust the routing discharges. The more critical variables could then be reentered into a flood routing program. Variations in the sediment entrainment and routing scenarios could then be used to establish variance in risks associated with different rainfall events.

Bridge Damage

Bridge damage along Highway 302 between Ormoc City and Baybay was extensive (Map 6). Bridge damages at Ormoc City and in other drainage are the result of over constriction of the stream at bridge crossings and poor alignment. Loss of bridge approach control structures, erosion around piers, deck uplift by debris and loss of abutment fill by piping were the common modes of failure (Photo 8). Most of the damaged bridges observed had constricted the river width by 50 percent or more. All bridges appeared to be constructed with near river bed spread footings at piers and gravity section abutments. Approach controls were grouted riprap with little if any toe burial and did not appear to always reach top of bank.

There were numerous cases where the banklines had eroded behind the bridge abutments. It is speculated that bridge constriction created a high differential head across the approach fill. Approach fill fines were piped out and a channel developed. Increasing the bridge length would help alleviate the problem under similar flood circumstances.

Other bridges failed because of river bed erosion below pier or abutment toes. Deeper footings, pile supported footings, and longer bridge sections in those cases would be beneficial.

River flow alignments appeared to be a major problem at bridge crossings. The alignment problems were, prior to the flood, partially corrected by grouted revetments.

Conclusions

The combination of topographic, hydrologic and physiographic features on the Island of Leyte leads to rainfall, sediment loading, runoff, and flood problems somewhat unique to steep, short, unstable drainage basins. Western slope drainage basins are more prone to intense runoff than are east slope drainages because of the higher average stream gradient. Flood frequency and net runoff during even modest severe rainfall events are dependent upon the cumulative effects of basin geology, topography, hydrology, and the geomorphic and antecedent moisture characteristics of the drainage basin prior to the event. Rainfall events of similar magnitude may result in very different flooding characteristics depending on event sequencing, antecedent moisture conditions in the basin and residual soil strengths. The flood of 5 November 1991 appears to be a product of event sequencing, rainfall intensity, and soil instability. In the 24 hours prior to the event, the basin had been subjected to significant precipitation. Landslides triggered mud and debris flows during the storm event. Moisture conditions in the drainage were high due to previous rains, and shortly after intense rains associated with typhoon Uring began, soils were totally saturated. Therefore, flow concentration times were short and side slopes were weakened to the point of failure. High precipitation bulking and perhaps the effect of the more viscose mud and water mix on channel roughness culminated in flow depths greatly exceeding channel capacity on the alluvial fan. The peak flow from the event was on the order of two times the flow that would have been expected if major sediment entrainment had not occurred.

Recommendations

The loss of life at Ormoc is considered the most severe impact of the flooding on Leyte. A significant reduction of this impact can be obtained by preventing habitation in high risk areas. The delta of the Antilao and Malbasag Rivers immediately upstream of Ormoc City Isla Verde Area was densely inhabited prior to the flood. Most of the deaths were among the residents of that particular area. It is now being resettled. Immediate action on zoning to prevent that rehabitation and enforcement of the zoning can go a long way toward mitigating a future disaster.

Another method of reducing loss of life in somewhat lower risk areas than the delta region are flood warning systems. The western slope of Leyte where Ormoc is located is probably not adaptable to this because of the short, steep drainage. Eastern slopes are however well situated for flood warning systems.

Flood control storage systems are measures used elsewhere to control runoff from major events, and have been mentioned in several of the Philippine Government agency reports. Onstream storage does not seem practicable at first assessment. The high sediment yield, steep stream gradients and incised nature of the channels normally make economic development of onstream storage difficult. On the western slopes, offstream storage also appears to be limited by topography. The eastern side may however benefit by offstream storage. Rice paddies and other natural impoundments may already be effective in attenuating major floods.

The frequency of an event is an important factor in determining risk and economic impact. Based on the memory of the population, the most recent flood prior to 5 November 1991 occurred in the 1930's. Rainfall records observed also indicate that the intensity of the 5 November 1991 event was the greatest in the 19-year period of record. The frequency and the magnitude of this and other events should be determined if economics is to be the basis for costly changes in design criteria for infrastructure or major flood control works. Zoning should also incorporate some logic on risk and risk assessment which depends on flood frequency and magnitude.

Numerous streams flooded during the Uring Typhoon event. Measurement of high flow marks, estimates of sediment yield by quantifying slides mass, and hydraulic analysis to establish peak flows combined with flood routings can establish the magnitude of the event. Event frequency may be more elusive as it is believed that it is a function of length of precipitation, intensity of precipitation and the slope stability of the basin at the time of the event. Methods that are used include population interviews, historic landslide analysis, storm frequencies including hindcasts and historic flow measurements. A combination of methods will probably be required in this situation.

Design criteria for infrastructure (i.e. bridges, revetments, power poles, and other items) appear to be based upon fairly modest climatic conditions and upon more tranquil drainage systems. A review of bridge design, river mechanics and international experience may indicate that a change in the design criteria could improve the life-cycle costs of the infrastructures.

The presently active slide areas will continue to yield sediments to the streams at a fairly high rate until naturally revegetated or otherwise stabilized. A storm of lower intensity and water content could produce a higher flow than Typhoon Uring under these circumstances as sediment bulking of the flow could be more pronounced. Steps taken to revegetate and stabilize the slides would reduce the period of risk.

Stream alignment improvements at bridges, hydraulic improvements through populated areas, or diversions around populated areas are possibilities for minimizing impacts. Extensive engineering analysis is required to define the benefits of such options.

<u>Bibliography</u>

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Yolo, Vicente A. Jr., (Submitted by). 1991. Typhoon Damages Reports with Pictures Caused by Typhoon "Uring" Occurred on 5 November, 1991, and Temporary Restoration Work, 3rd Leyte Engineering District Baybay, Leyte Republic of the Philippines.

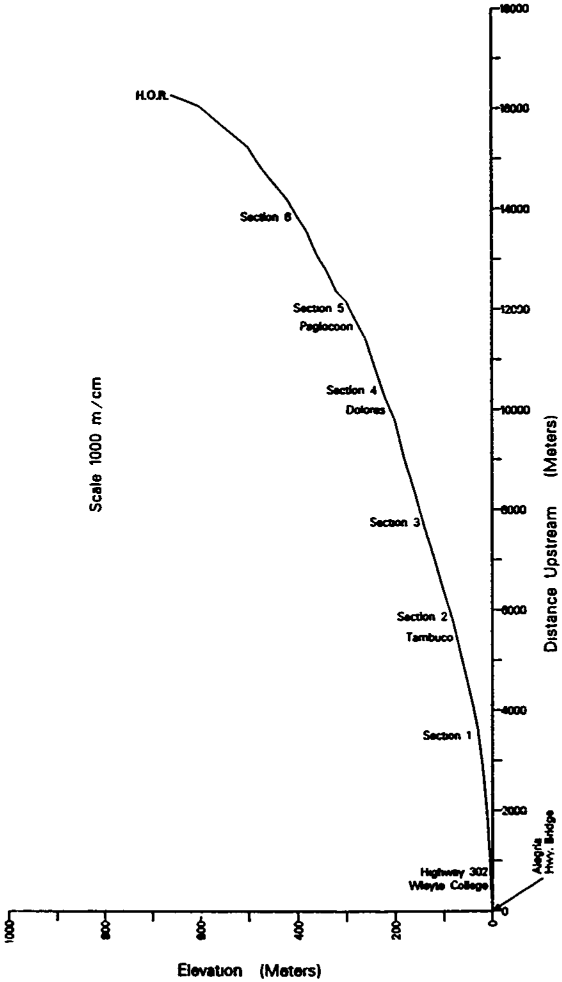


Figure 1. Antilao River Channel Profile and Cross-Section Stationing

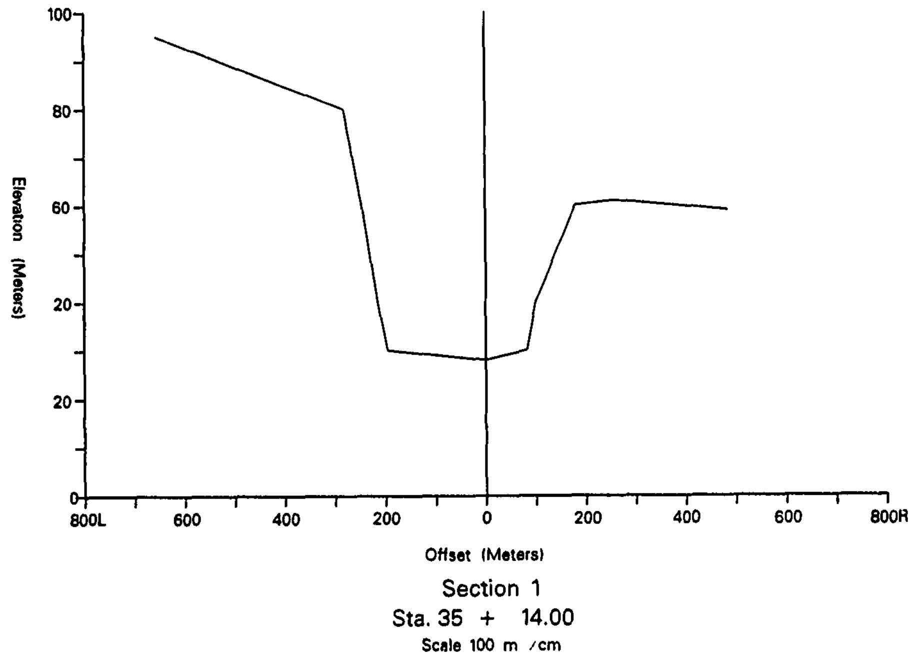


Figure 2. Cross Section 1 Antilao River

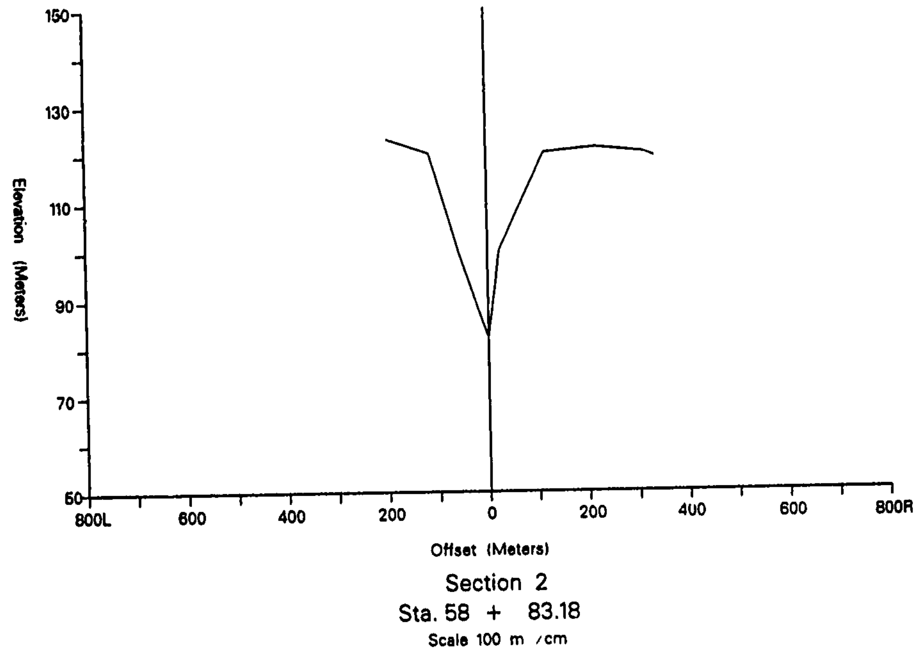
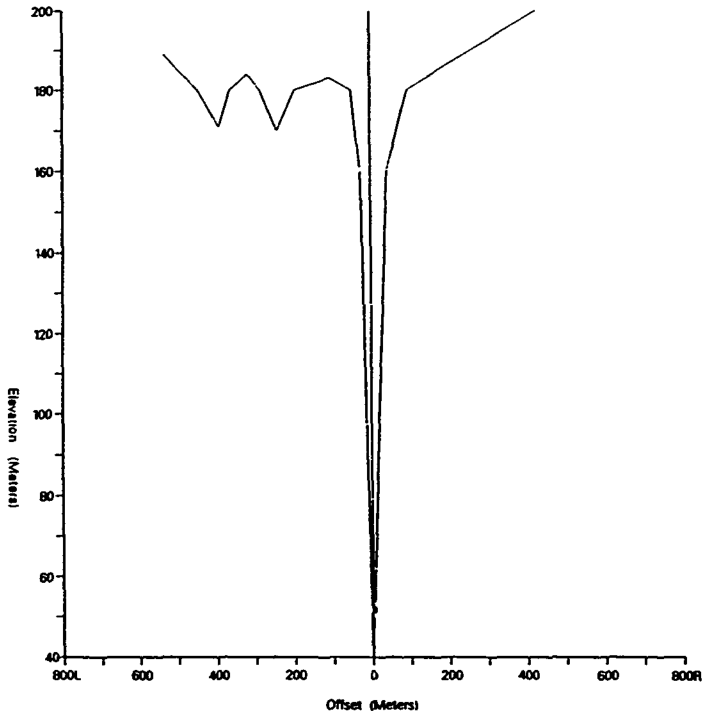


Figure 3. Cross Section 2 Antilao River



Section 3
Sta. 77 + 65.08
Scale 100 m /cm

Figure 4. Cross Section 3 Antilao River

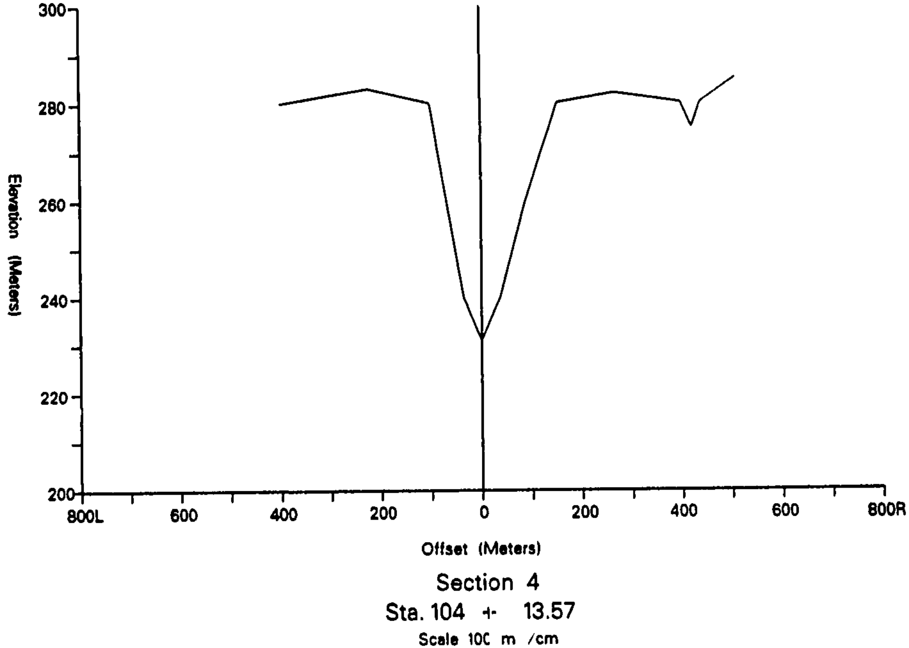


Figure 5. Cross Section 4 Antilao River

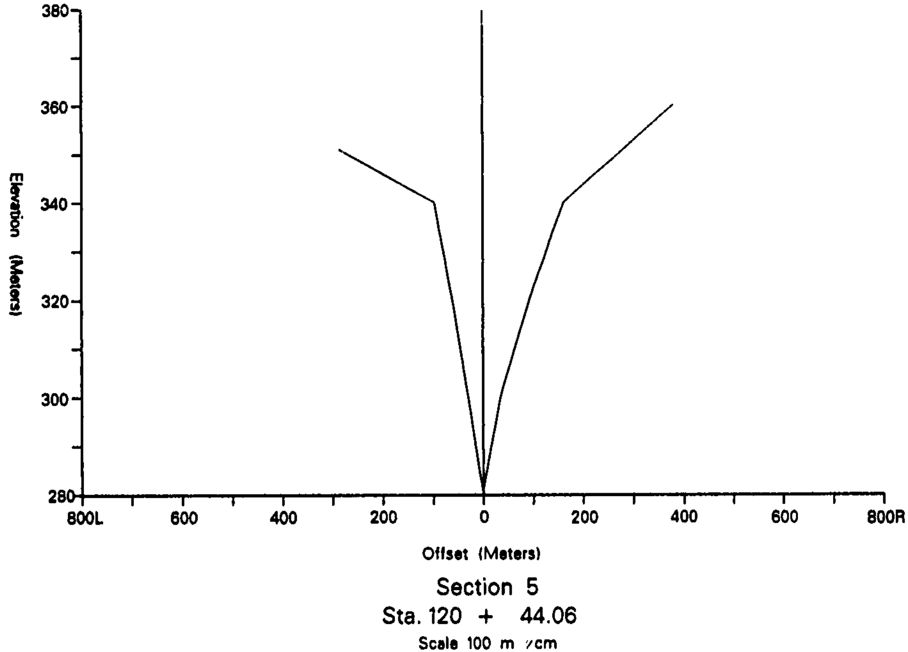


Figure 6. Cross Section 5 Antilao River

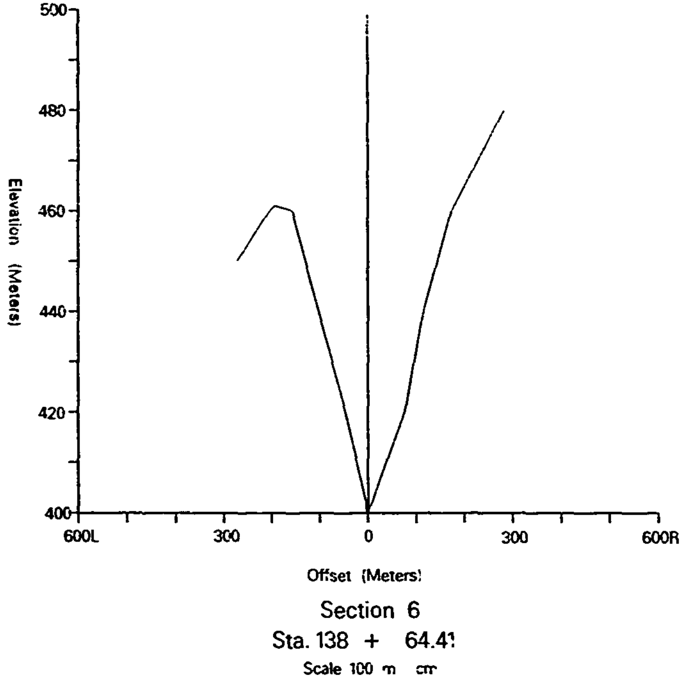


Figure 7. Cross Section 6 Antilao River

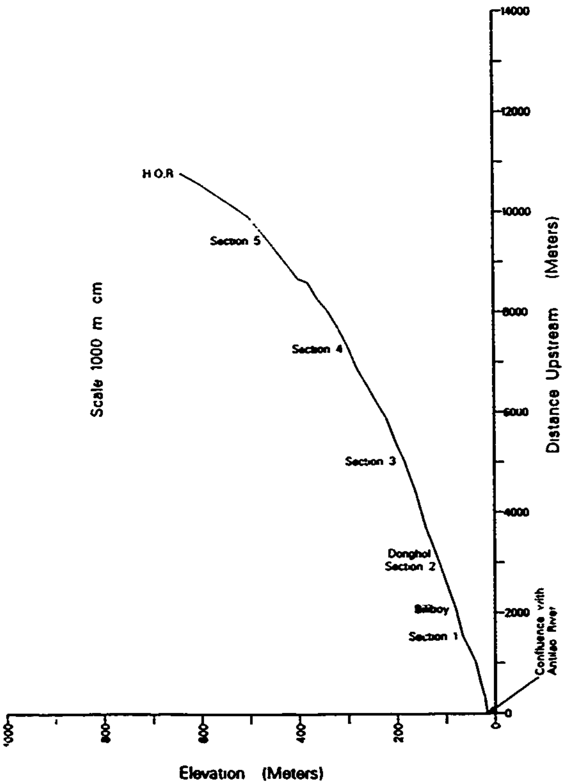


Figure 8. Malbasag River Channel Profile and Cross-Section Stationing

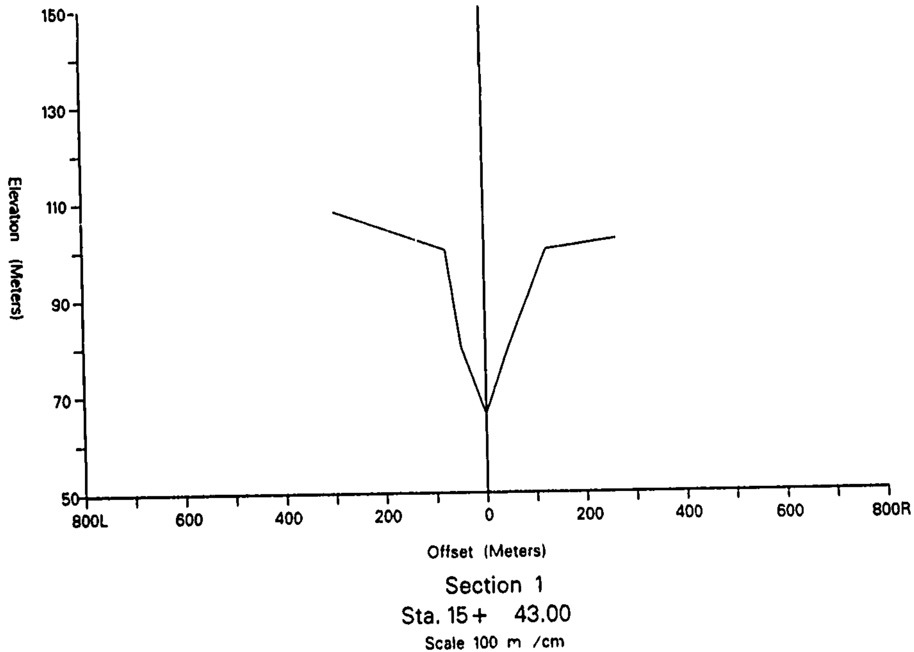


Figure 9. Cross Section 1 Malbasag River

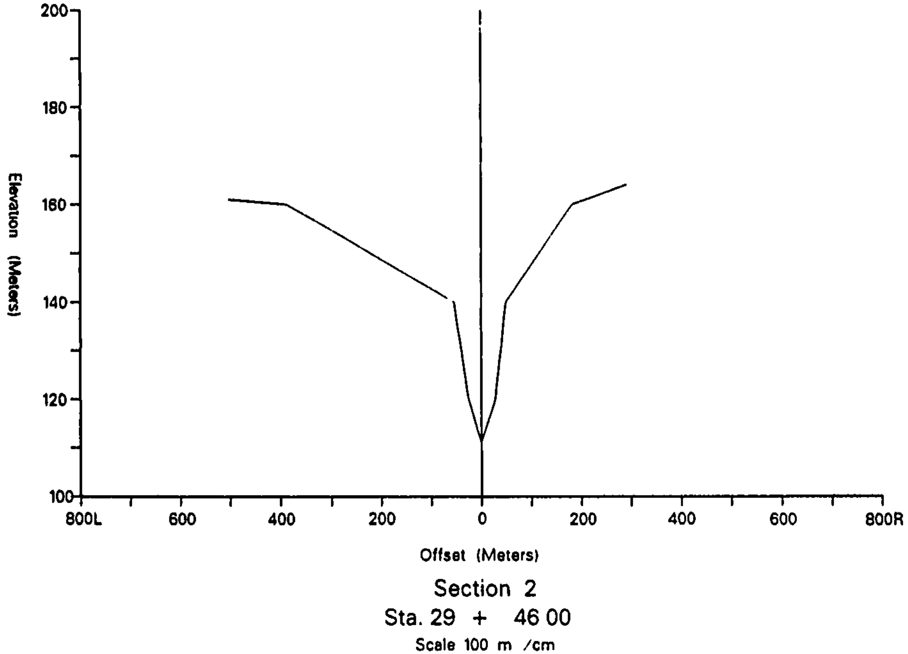


Figure 10. Cross Section 2 Malbasag River

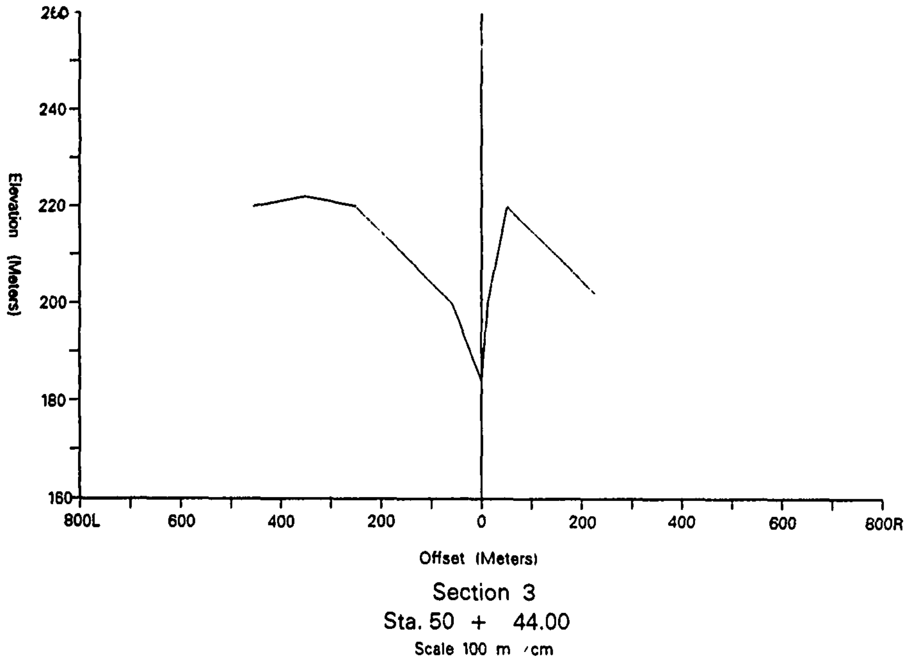


Figure 11. Cross Section 3 Malbasag River

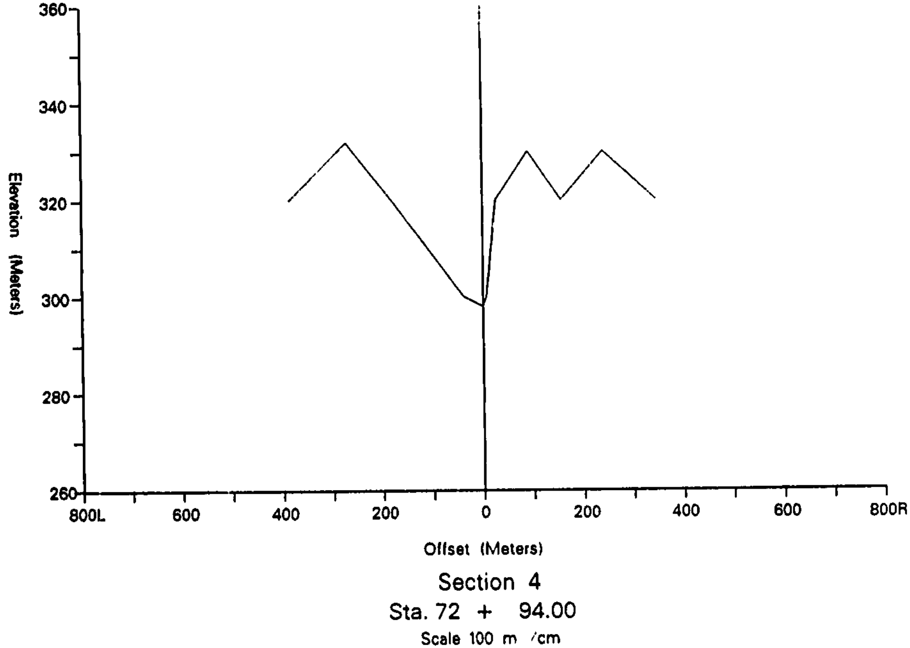


Figure 12. Cross Section 4 Malbasag River

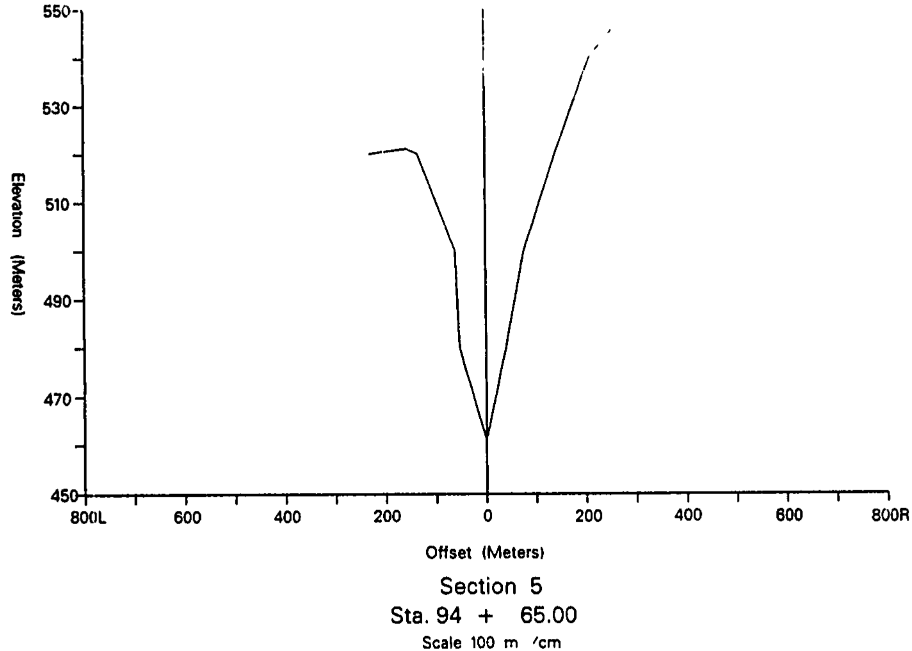


Figure 13. Cross Section 5 Malbasag River

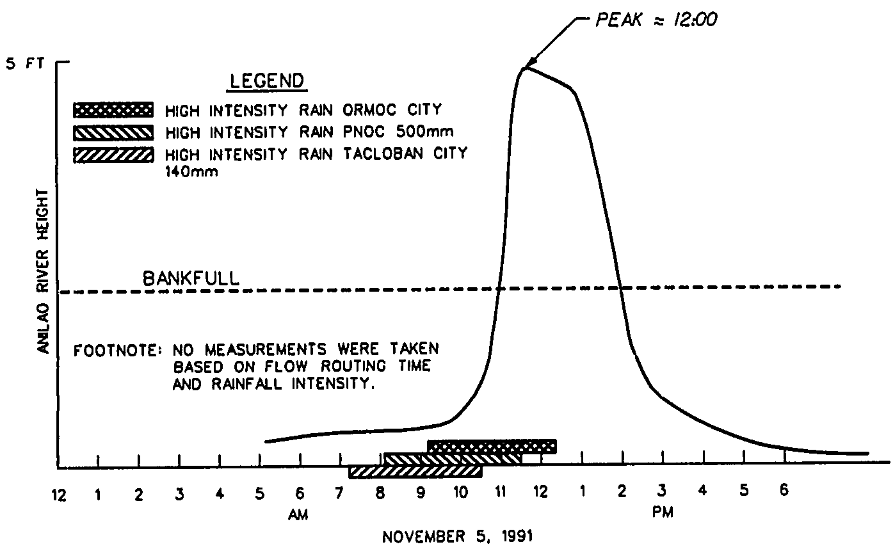


Figure 14. Antilao River Stage Hydrograph at Ormoc City

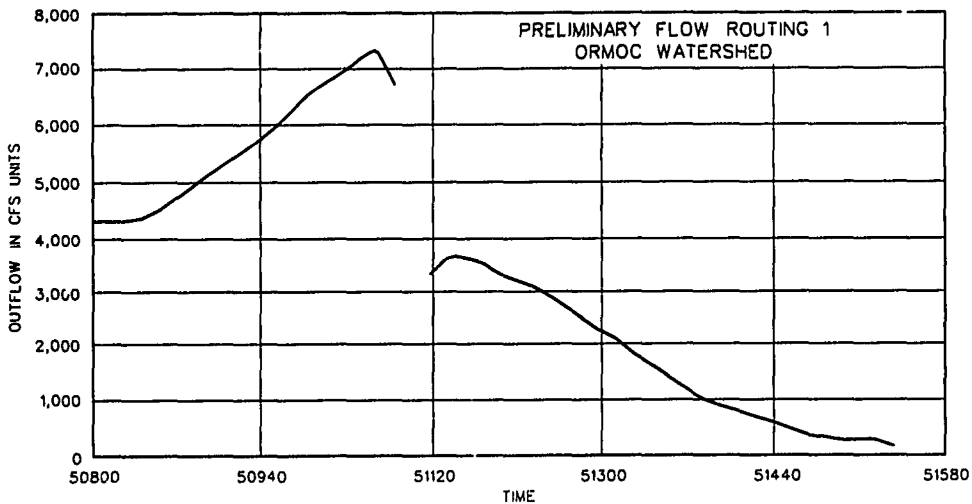


Figure 15a. Flood Routing #1 for Ormoc Watershed

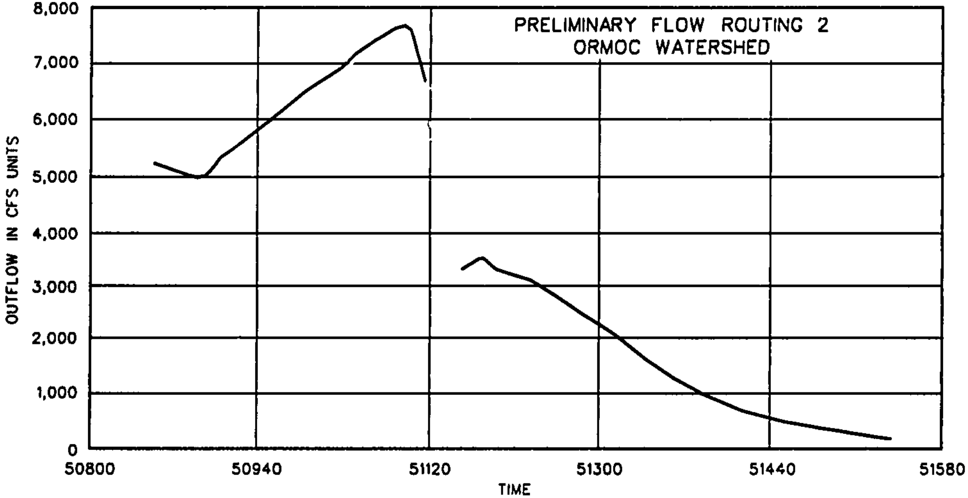
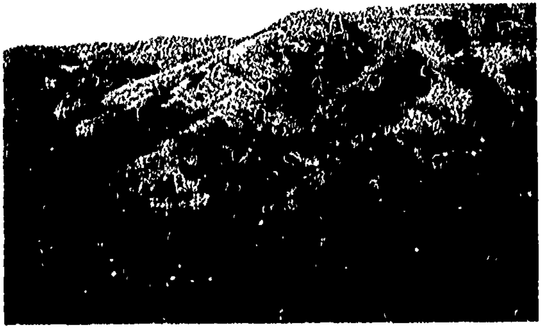
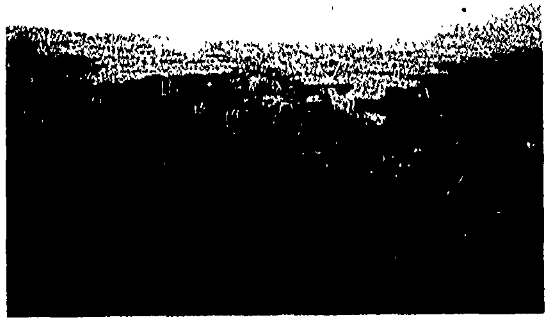


Figure 15b. Flood Routing #2 for Ormoc Watershed



a. UPPER DRAINAGE BASIN ORMOC WATERSHED
ANTILAO RIVER

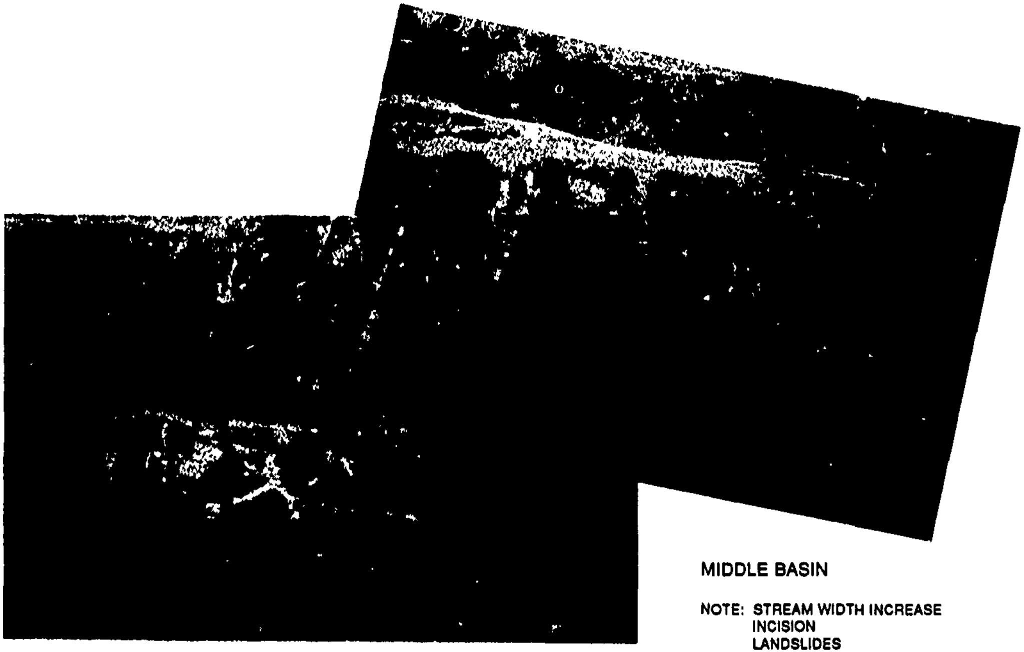
NOTE. CHANNEL INCISION
LANDSLIDE DEPTH AND LENGTH
STREAM SIDE SLOPES



b. LOOKING DOWN SYSTEM TO ORMOC CITY

NOTE: DENDRITIC CHANNEL PATTERN

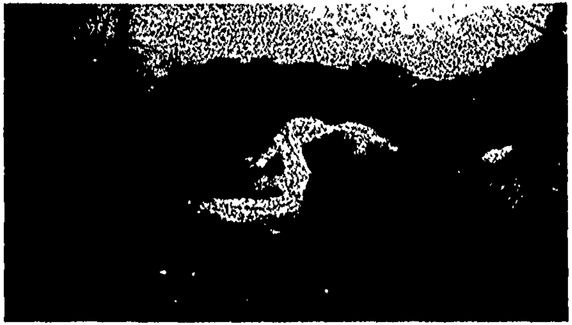
PHOTO PLATE 1



MIDDLE BASIN

NOTE: STREAM WIDTH INCREASE
INCISION
LANDSLIDES
STREAM SIDE SLOPES

PHOTO PLATE 2



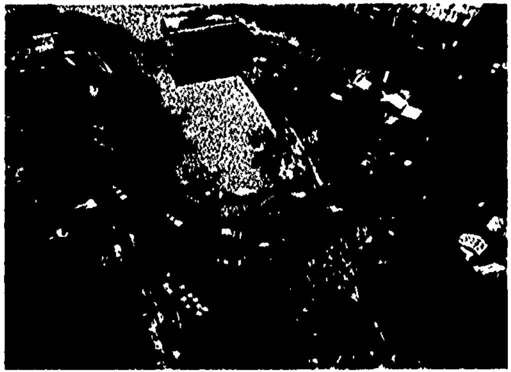
LOWER BASIN

NOTE CHANNEL MEANDERS
INCISION
DECREASE IN CHANNEL SIDE SLOPE
REDUCTION IN LAND SLIDE OCCURRENCE

PHOTO PLATE 3

a. WOODY DEBRIS DEPOSITION AREA UPSTREAM OF ANTILAO RIVER BRIDGE

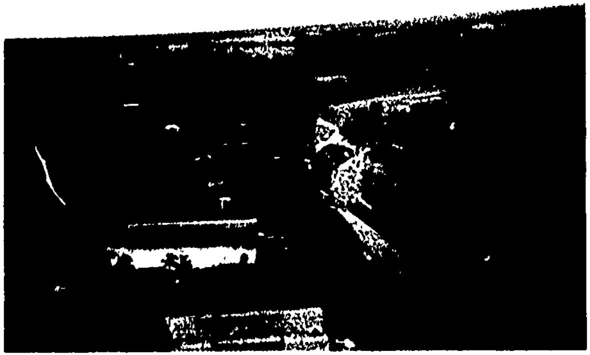
NOTE: 1. CHANNEL MAKES 90° BEND AT THIS LOCATION
2. FLOW MOMENTUM DIRECTED TO RIGHT OF PHOTO WHICH IS PROBABLE 1ST OVERFLOW ZONE INTO CITY



b. TYPICAL CHANNELIZED SECTION THROUGH ORMOC CITY

NOTE. FAILED RIVER BRIDGE

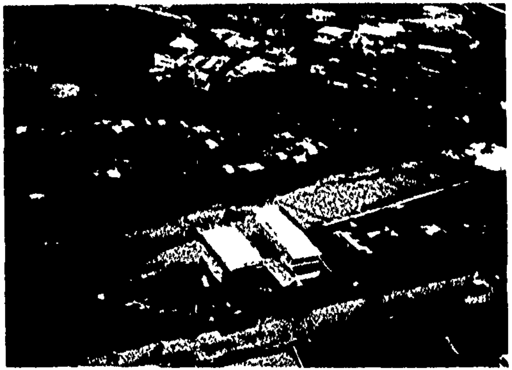
PHOTO PLATE 4



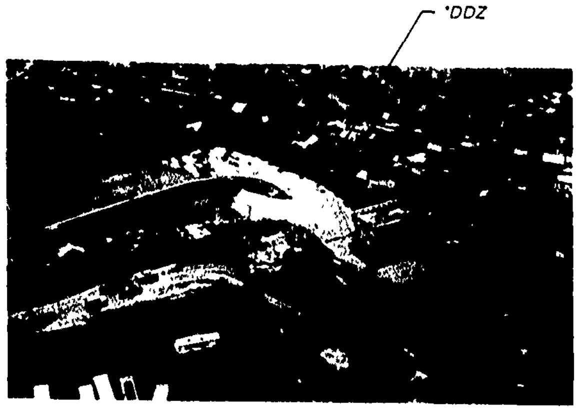
a. ANTILAO RIVER UPSTREAM OF ISLA VERDE AREA
ANTILAO RIVER AND MALBASAG RIVER
CONFLUENCE AREA

b. FLOOD PLAIN HABITATION AREA
U/S OF ORMOC BRIDGE AND
HIGHWAY 302 TRAINING OF
ANTILAO RIVER, MALBASAG RIVER

PHOTO PLATE 5



a. FLOOD PLAIN REHABITATION
ISLA VERDE AREA



b. ANTILAO BRIDGE AT ORMOC

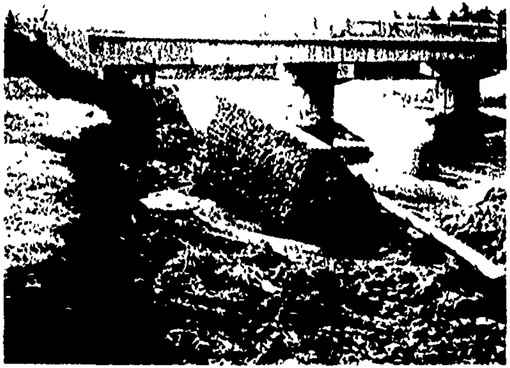
NOTE: CHANNELIZATION DOWNSTREAM OF FAILED
BRIDGE STRUCTURE 90° CHANNEL BEND
DEBRIS DEPOSITION ZONE
'DDZ = DEBRIS DEPOSITION ZONE

PHOTO PLATE 6

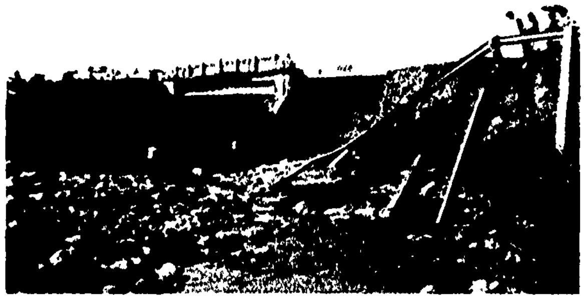
TREE BLOW DOWN UPPER ORMOC WATERSHED

NOTE. LARGE SHALLOW MASS FAILURES

PHOTO PLATE 7

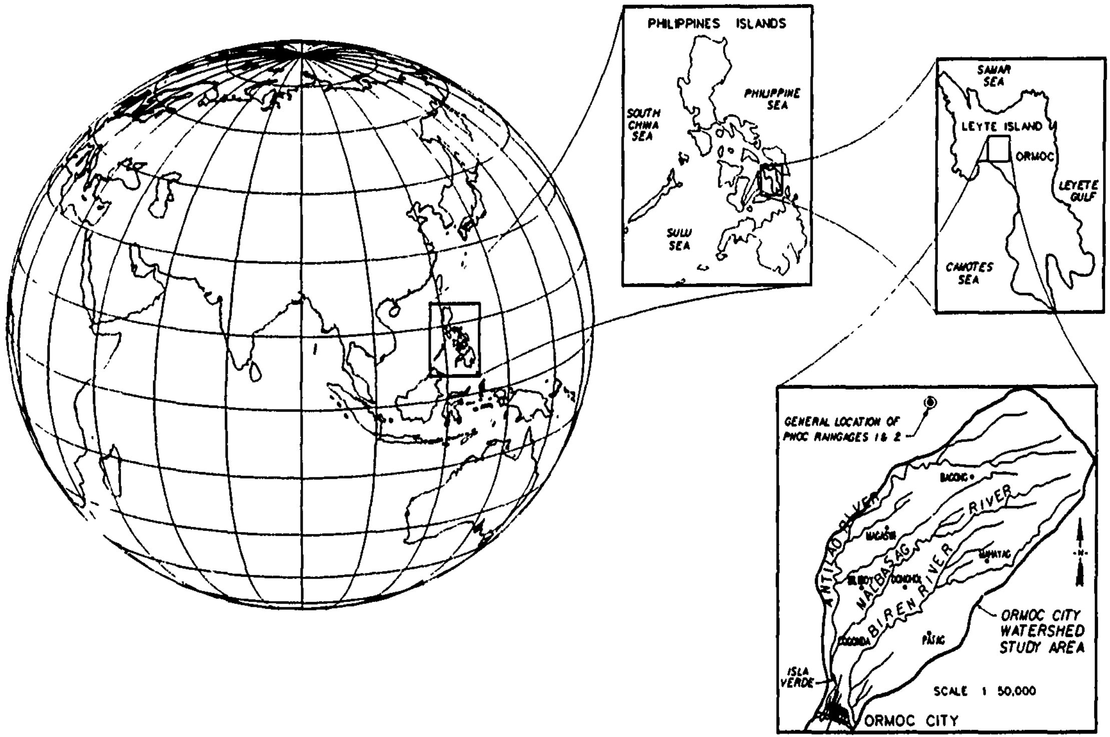


a. BRIDGE FAILURE PALANAS BRIDGE

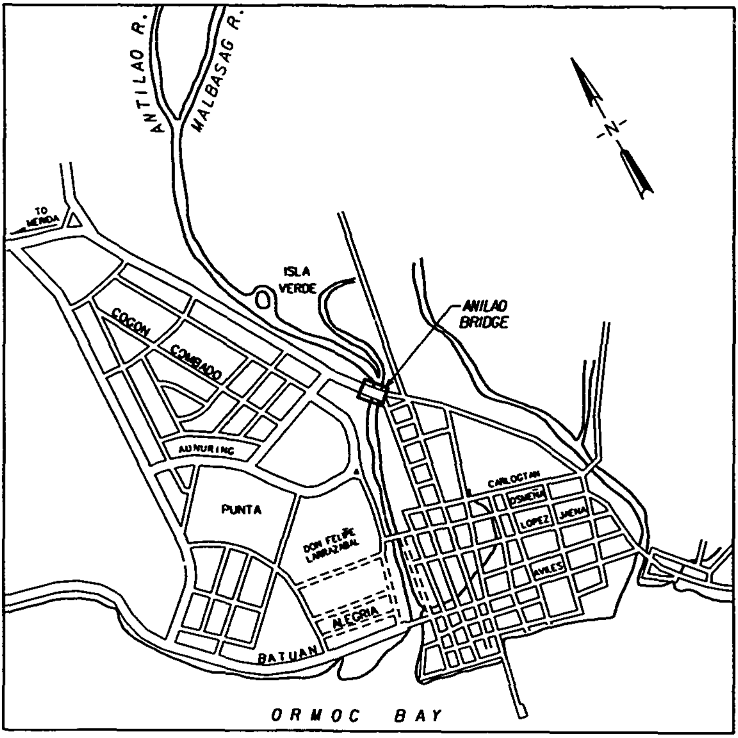


b. BRIDGE FAILURE CALGIGA-A BRIDGE

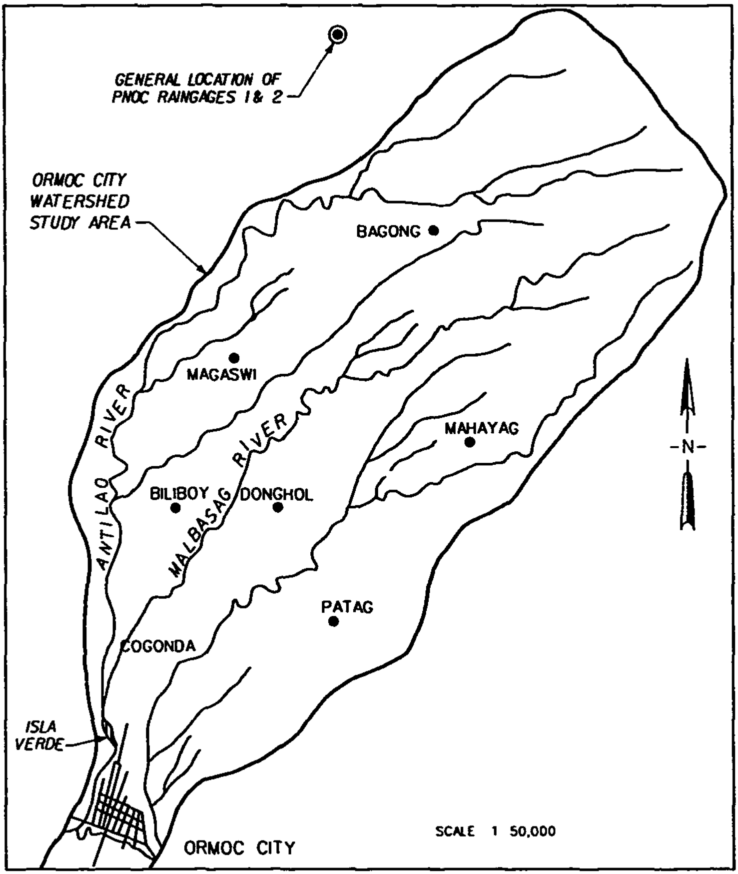
PHOTO PLATE 8



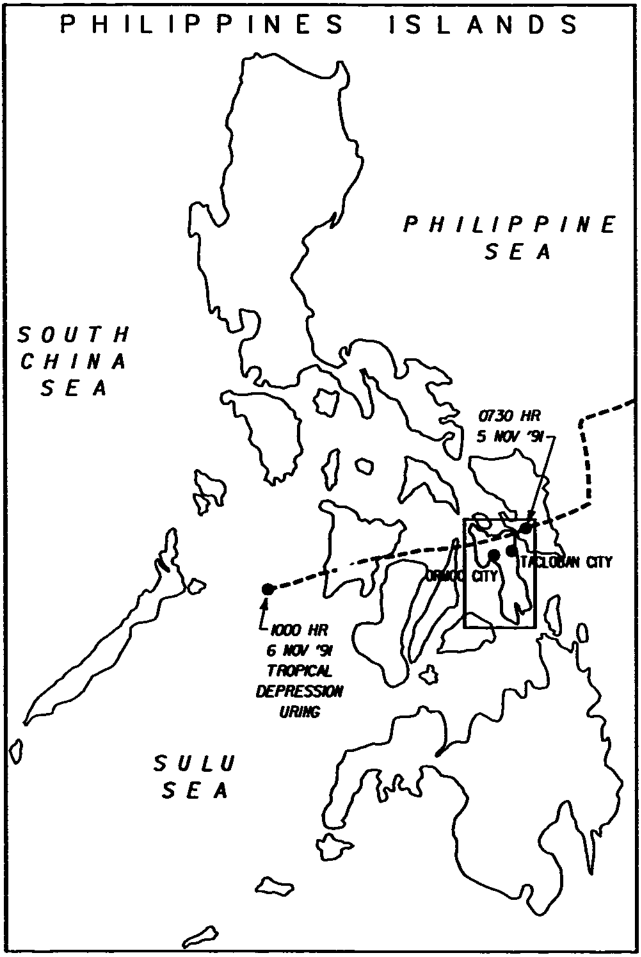
Map 1. Location Map, Ormoc Watershed, The Phillippines



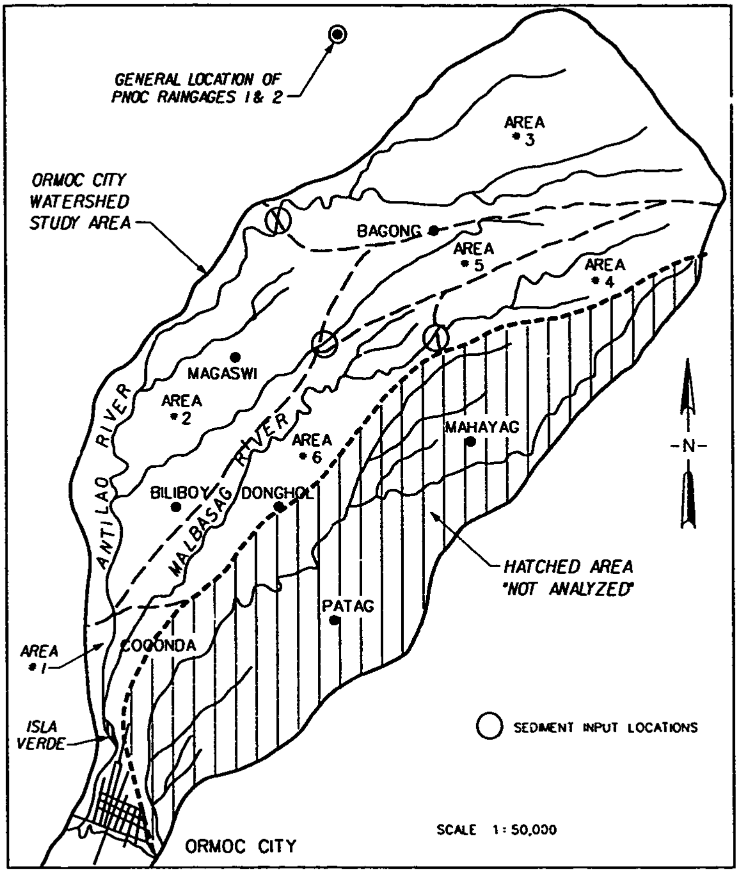
Map 2. Ormoc City Area Map, Two Rivers and Flooded Areas



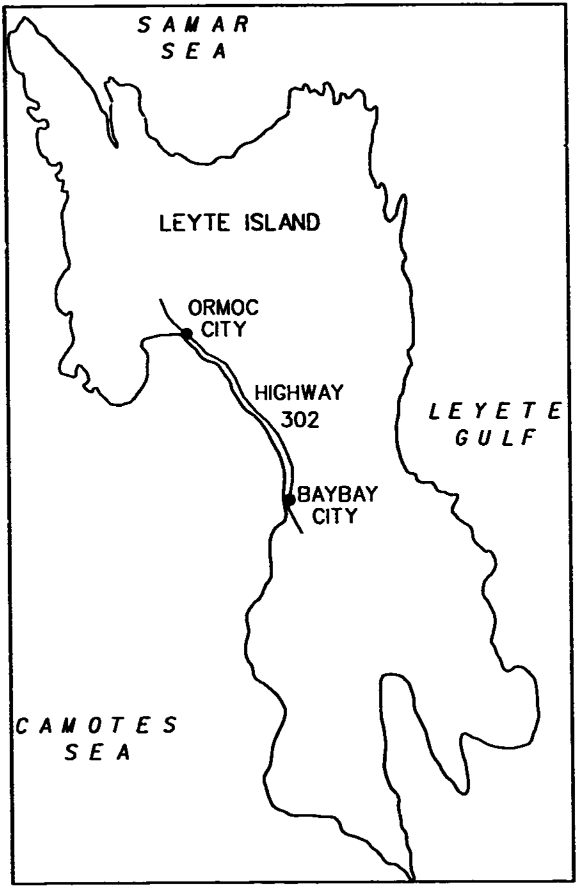
Map 3. Ormoc Watershed



Map 4. Storm Track for Typhoon URING



Map 5. Sediment Routing Basin Map



Map 6. Ormoc City to Baybay Leyte
Coastal Highway No. 302

Appendix A: List of Contacts

Vicente Paragas	Regional Technical Director, Department of Environment and Natural Resources
Rosalio Goze	Regional Executive Director, Department of Environment and Natural Resources
John Sturnes	U.S. AID Office of Capital Projects, U.S. State Department
Bob Vergara	U.S. AID Office of Capital Projects, U.S. State Department
Abelardo M. Monge, Jr.	Assistant Regional Director for Services, Department of Public Works and Highways
Pacifico G. Mendoza, Jr.	Regional Director, Department of Public Works and Highways
Eriverto V. Loreto	Congressman, 5th District, Leyte
Carment L. Cari	Mayor, Baybay, Leyte
Ruben Penserga	City Engineer, Ormoc, Leyte
Ramon Omega	District Engineer, Leyte 2, Department of Public Works and Highways
Leonardo A. Nunez	Director, Bureau of Maintenance, Department of Public Works and Highways
Fortunato Dejoras	Administrator, Office of Civil Defense
Romulo M. del Rosario	Undersecretary, Bureau of Maintenance, Department of Public Works and Highways
Vicente Yulo	Third Leyte Engineering District, Assistant District Engineer
Minni Dilgo	Philippine National Oil Company, Assistant Service Manager
Janparralla	Weather Data

ENGINEERING OFFICER
USAID/Philippines

Date: 05 December 1991

To: File

Subject: ORMOC DISASTER
Corps of Engineers

Revised agenda for evaluation team:

05 DEC 91	2250 hrs	Team arrives NAIA
05 DEC 91	2320 hrs	Team departs NAIA for Sheraton
05 DEC 91	2350 hrs	Team arrives at Sheraton
06 DEC 91	0845 hrs	USAID vehicle picks up Team at Sheraton for travel to RMC
06 DEC 91	0900 hrs	Team arrives at RMC and meets with USAID technical staff
06 DEC 91	1100 hrs	Team meets with USAID Director
06 DEC 91	1330 hrs	Team departs RMC for DPWH
06 DEC 91	1400 hrs	Team meets with DPWH Undersecretary
06 DEC 91	1530 hrs	Team departs DPWH for Sheraton
06 DEC 91	1600 hrs	Team arrives at Sheraton
08 DEC 91	1430 hrs	USAID vehicle picks up Team at Sheraton for travel to Manila domestic airport
08 DEC 91	1500 hrs	Team arrives at Manila domestic airport
08 DEC 91	1600 hrs	Team departs Manila via PAL
08 DEC 91	1705 hrs	Team arrives Tacloban
09 DEC 91	0830 hrs	Team departs Tacloban for Ormoc via GOP helicopter
09 DEC 91	1600 hrs	Team departs Ormoc for Tacloban via GOP helicopter
10 DEC 91	0830 hrs	Team departs Tacloban for Ormoc via GOP helicopter
10 DEC 91	1500 hrs	Team departs Ormoc for Tacloban via GOP helicopter
10 DEC 91	1805 hrs	Team departs Tacloban via PAL
10 DEC 91	1940 hrs	Team arrives Manila
11 DEC 91		Team drafts report and prepares for exit briefing
12 DEC 91		Team drafts report and prepares for exit briefing
13 DEC 91	0800 hrs	USAID vehicle picks up Team at Sheraton for travel to RMC
13 DEC 91	0815 hrs	Team arrives at RMC and meets with USAID technical staff
13 DEC 91	0830 hrs	Team gives exit briefing at USAID
13 DEC 91	1030 hrs	Team departs RMC for DPWH

Ak

13 DEC 91	1100 hrs	Team arrives at DPWH and gives exit briefing
13 DEC 91	1230 hrs	Team departs DPWH

Bob Vargara, a USAID Foreign Service National engineer assigned to the region which includes Ormoc, and John Starnes, USAID Engineering Officer, will accompany the team to Ormoc. USAID/Manila does not have a fund cite for your local transportation; therefore, be prepared to pay approximately $100 (P2683.50) each for your roundtrip air fare (Manila-Tacloban-Manila) and claim reimbursement for same on your travel voucher.

Director Leonardo A. Nunez of the Bureau of Maintenance in the DPWH appears to be taking the lead on the GOP side and will accompany the team to Ormoc. Mr. Fortunato Dejoras (National Disaster Coordinating Council) will also accompany the team.

John C. Starnes
Office of Capital Projects

REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
OFFICE OF THE SECRETARY
MANILA

RECEIVED
NOV 20 1 58 PM '91
110718
USA:D/C&R

November 19, 1991

MR. MALCOLM BUTLER
Director
United States Agency for
International Development
Manila, PHILIPPINES

LP
MM

ATTENTION: MR. LEROY PURIFOY
Chief Engineer, OCP

REFERENCE: TYPHOON URING DAMAGE ASSESSMENT

SUBJECT: REQUEST FOR THE ENGAGEMENT OF A SHORT TERM DISASTER EVALUATION TEAM BY USAID

Dear Mr. Butler:

The Department of Public Works and Highways is undertaking an investigation to determine the cause of the flooding which devastated Ormoc and the surrounding communities following Typhoon Uring in early November 1991. We therefore seek the assistance of USAID in providing a team of disaster evaluation specialists from the US Army Corps of Engineers who will help the Department in the evaluation of the damage and in providing insight to the cause and possible mitigation measures for the disaster.

We hope that USAID will consider this request favorably and assign the specialist team as soon as possible. DPWH is grateful to USAID for their continued assistance and cooperation in our efforts to rehabilitate disaster areas in the Philippines.

Sincerely,

TEODORO T. ENCARNACION
Undersecretary

DUE DATE
12-2-91

ACTION TAKEN
Name ______ Office ______
Type ______ No. ______
Date ______ Initials ______

A6

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

Ramon Magsaysay Center
1680 Roxas Boulevard
Ermita 1000, Manila
Philippines

Fax No.: 632-521-5241
Tel. No.: 632-521-7116

FAX TO: RAY DIONNE
OFDA/AID/W

FAX NO: (202) 647-5269

This is a formal request for the River Morphologist. I have sent you by separate fax some comments to help you in working out his contract and costs. This is the formal request. We have the attached letter from the GOP asking for this help. The report will be a report to the GOP and the USG. The report for the GOP to go to the Department of Public Works and Highways and the USG to OCP.

Bryant George
M D R O
11/20/91

Attachment: a/s

wp/bgdoc./11/20/91

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

Ramon Magsaysay Center
1680 Roxas Boulevard
Ermita 1000, Manila
Philippines

Fax No.: 632-521-5241
Tel. No.: 632-521-7116

November 20, 1991

Mr. Ray Dionne
Office of Foreign Disaster
Assistance/ASP Room 1052 NS
AID Washington, D.C. 20523

Ray,

Thank you for forwarding the scope of work proposed by the River Morphologist. We have the following comments:

1. The base of operation needs to be Tacloban or Ormoc, very adequate accommodations are available. Manila is far too far away from this location to be of use as a base. This would be about an 4 hour a day commute.

2. We will attempt to get helicopter from private companies in the area or AFP. Again, its too far from the Subic Assets, the team we have down there now just notified me that they are taking a bus from one location to another. Then choppers did not materialize because of the newest storm Yayang, which makes it impossible to fly. Basically, we cannot guarantee that there will be helicopter support the whole time but we can guarantee that there will be some helicopter support. However, a great deal of this is going to have been done over muddy roads and none to secure bridges.

3. We can arrange for full meeting with and debriefing by the Dept. of Public Works and Highways (DPWH) people of the country and meeting with the DAST people who have made their evaluation of the area on November 15, 1991. In addition, we have excellent contacts with the shipping line people and transport people who handle all of the freight to and from Ormoc from Cebu City.

4. The per diem for Ormoc is $45.00 a day (lodging is $23.00 & meals are $22.00). The per diem for Tacloban is $57.00 a day (lodging is $39.00 & meals are $18.00).

5. We will make a formal request for the service of this man/men as soon as we get a formal request from the GOP. This is a highly sensitive issue and we must have a GOP Agency ready to handle the flack that surely will arise from any report that the USG develops no matter how it is vetted.

Best Wishes,

Bryant George
Chief
Office of Food For Peace
and Voluntary Cooperation

11/22/91 08:41 ☎ 202 272 0824 --> CENPD PE-IE P.05

Appendix B   Rainfall Data NPOC

APPENDIX B

PHILIPPINE NATIONAL OIL COMPANY (PNOC) RAINGAGE 1 & 2 DATA, LEYTE

DAILY RAINFALL DATA (in mm/day)
For the month of November 1991

DATE	STATIONS		DAILY TOTAL	DAILY AVERAGE	REMARKS
	1	3			
1	Nil	Nil	–	–	
2	0.8	1.2	2.0	1.8	
3	4.5	2.1	6.6	3.3	
4	21.0	15.0	36.0	18.0	
5	580.5	350.0	930.5	465.2	Typhoon "Uring"
6	46.0	41.8	87.8	43.9	
7	Nil	Nil	–	–	
8	Nil	Nil	–	–	
9	Nil	Nil	–	–	
10	Nil	Nil	–	–	
11	Nil	Nil	–	–	
12	Nil	Nil	–	–	
13	Nil	Nil	–	–	
14	Nil	Nil	–	–	
15	10.0	14.3	24.3	12.1	
16	76.0	70.0	146.0	73.0	Typhoon "Yayang"
17	Nil	Nil	–	–	
18	Nil	2.5	2.5	1.2	
19	Nil	Nil	–	–	
20	Nil	Nil	–	–	
21	17.5	10.7	28.2	14.1	
22	69.3	65.7	135.0	67.5	
23	58.0	78.8	136.8	68.4	
24	32.2	32.0	64.2	32.1	
25	1.4	3.0	4.1	2.0	
26	3.0	1.0	4.0	2.05	
27	8.0	7.0	15.0	7.5	
28	0.1	Nil	–	–	
29	Nil	Nil	–	–	
30	Nil	Nil	–	–	
31	Nil	Nil	–	–	

Monthly precipitation in 2 stations	→ 1608.0
Total monthly average precipitation/station	→ 804.0
Average daily precipitation	→ 26.7
RECORDED BY: *J.R. Rallo*	*VERIFIED BY:* *R.S. Alincastre*

LOCATION OF RAINGAUGE STATIONS:

1 – EDC Campsite Cabalonan
2 – TGE 11

RSA/jar:ilb

Table 1

Monthly Rainfall (in mm) for VISCA Station North of Baybay Leyte

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1976	421.1	199.1	269.4	40.6	115.6	261.9	161.6	419.3	128.5	125.3	146.9	468.8
1977	176.9	434.9	125.7	46.7	121.8	203.9	337.5	377.2	80.2	76.3	224.2	62.3
1978	241.7	139.3	178.8	130.3	179.9	142.0	214.7	424.2	462.9	478.4	181.5	472.7
1979	150.1	57.9	42.7	190.9	138.8	304.1	237.7	81.6	209.4	244.9	269.6	263.1
1980	356.9	277.6	57.7	149.4	24.9	357.9	271.2	511.9	298.4	191.7	506.9	230.9
1981	431.8	87.6	41.9	70.1	91.8	363.0	293.8	123.7	282.7	273.8	297.0	266.3
1982	84.3	195.3	316.6	123.5	77.2	130.1	385.9	361.6	126.9	224.1	176.6	73.0
1983	137.0	29.3	17.2	19.4	6.2	124.3	413.3	251.6	224.2	144.0	156.1	603.7
1984	334.1	415.9	179.3	137.0	60.5	83.4	165.1	194.5	122.6	252.7	221.6	371.7
1985	359.3	150.5	106.1	103.0	160.8	121.3	292.4	194.8	399.2	196.0	152.0	133.4
1986	500.1	107.8	163.5	156.6	87.2	176.9	117.7	441.6	128.0	301.2	248.4	183.1
1987	261.8	156.9	90.9	11.7	10.8	16.2	284.0	289.4	77.7	113.4	378.9	83.1
1988	134.1	134.1	64.8	183.7	56.4	251.9	113.3	184.3	201.1	252.0	329.7	253.0
1989	593.9	265.0	208.5	164.9	165.1	259.9	343.4	135.1	109.6	254.2	180.0	129.6
1990	438.0	60.7	22.7	87.2	213.8	365.5	268.5	149.8	290.1	588.0	535.0	175.4
1991	219.1	307.6	145.7	132.6	169.6	204.5	326.9	209.6	154.2	208.0	489.1	No Data
1992	100											

Waterways Experiment Station Cataloging-in-Publication Data

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