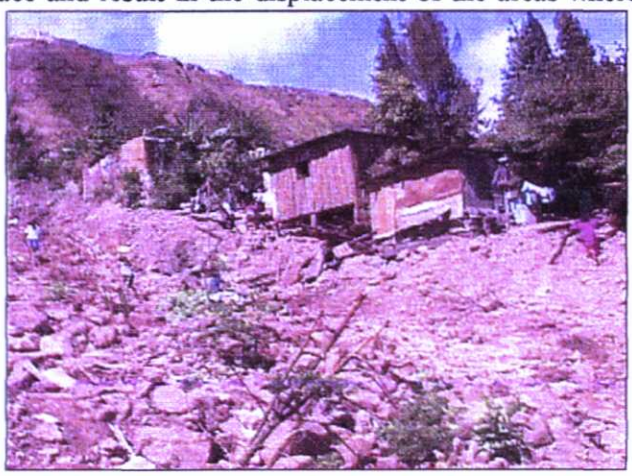
landslide, which destroyed hundreds of homes in the Colonia Soto (approximately 5 to 7 million cubic meters of material).

In addition to the flooding, extensive sediment deposition occurred, including incursion of the El Berrinche landslide into the Rio Grande Choluteca, has reduced channel capacities in the Rio Grande Choluteca and its tributary channels throughout the urbanized areas of Tegucigalpa. It is estimated that 4,400 houses were destroyed (and 6,600 homes damaged) within the Francisco Marazon Department.

Landslides

El Berrinche: Portions of two colonias, El Porvenir and 14 de Febrero, sit at the head scarp of the El Berrinche landslide on the upper right and upper left sides (looking upslope) respectively. Tension cracks from the head-scarp area of the landslide extend into each of these colonias near houses that are sitting adjacent to the head scarp. In the next rainy season, additional slumping from the head scarp area is likely to take place and result in the displacement of the areas where houses sit next to these cracks. Continued movement may take place for several years in which portions next to the head scarp area of the landslide may slump onto the present landslide mass in a retrogressive (progressing upslope) manner. Residences adjacent to the head scarp of the El Berrinche landslide might be evacuated and the occupants relocated especially if tension cracks now extend within the houses or within several meters of individual houses. If not evacuated, these areas of houses need to have survey markers established near them and monitored at regular intervals so that any renewed movement can be detected and the people warned of imminent movement and slope failure



Homes in Colonia El Porvenir perch dangerously close to the El Berrinche slide.

Colonia El Reparto: Several houses within Colonia El Reparto are located near the upper left side (looking upslope) of the head scarp of the El Reparto landslide. Similar to the situation in those colonias near the El Berrinche landslide, these homes in Colonia El Reparto are located within 10 meters of the landslide head scarp. No cracks are presently evident extending immediately adjacent to the houses, and the residences may escape involvement in renewed slumping from the head-scarp region of the landslide in the next rainy season. However, survey markers need to be

El Reparto landslide that destroyed numerous homes

placed above the head-scarp area near these houses so that any recurring movement can be detected and the people warned. People should then be evacuated at the first sign of renewed movement indicating that the houses are becoming part of retrogressive slumping that is likely to take place in the head-scarp of the landslide for several years.

Flooding

Extensive sediment deposition has greatly reduced the bridge capacities in Tegucigalpa

The major rivers in the Tegucigalpa area peaked in the late night and early morning hours of 30-31 October 1998. In addition to extensive flooding, the high peak flows caused significant scour and erosion of the streambanks resulting in the destruction of numerous homes as well as the destruction of several bridges. Along the Rio Choluteca and Rio Chiquito in Tegucigalpa, floodwaters engulfed dwellings located more than 3 city blocks from the rivers, where substantial damaged to homes and businesses occurred, as well as deposition of mud and debris several meters deep when floodwaters subsided. The downstream toe of El Berrinche landslide dammed the Choluteca River resulting in substantial aggradation of sediment in the river channel for approximately 1 to 2 km upstream of the slide. Due to the tremendous amount of sediment which has been introduced into the entire river drainage system, higher than normal rainy season flows/floods can be expected over the next few seasons. Sediment deposition will re-occur in the dredged rivers, resulting in additional channel maintenance costs in the future as the channel re-adjusts to the increased sediment availability due to Hurricane Mitch.

Mitigation Measures

- *(Short Term)* The city of Tegucigalpa should prohibit residents from rebuilding homes on the El Berrinche and El Reparto slides.

- *(Short Term)* The city of Tegucigalpa should prohibit any reconstruction within one block (approximately 100 meters) of the river until further floodplain studies are conducted to better define flood risks.

- *(Short to Long Term)* To fully mitigate the present and future landslide hazards that may occur from the El Berrinche landslide, a complete geotechnical sampling, testing, instrument installation, stability analysis, and mitigation program would need to be undertaken. The sampling, testing, and instrument monitoring of the landslide and its materials would allow the calculation of the present factor of safety and the conditions with respect to groundwater levels under which the landslide would begin to show additional movement. Such a stability analysis may suggest the specific mitigation measures to be undertaken. Such a program of data collection and analysis would cost approximately $500,000 to $750,000. Mitigation and construction efforts to prevent future landslide movement would depend on the results of the analysis; however, such measures as the installation of retaining structures and surface and subsurface drainage would likely be around $1.5- to $2.0-million.

- *(Short Term)* In lieu of the above remedy to future landslide movement, inexpensive measures can be undertaken to decrease the risk of renewed landslide movement. Water continues to flow over the head-scarp area forming a pond on the upper reaches of the landslide near Colonia 14 de Febrero. Diverting the surface flow of water from the landslide mass would help to prevent saturation of the slide mass. Also, water emanating from the landslide mass should also be channeled off of the mass to remove as much water from the landslide as possible. Lined surface channels to divert and drain surface waters should be constructed to remove water from the landslide and prevent it from saturating other adjacent slopes.

- *(Short Term)* Regrading the landslide surface to seal open cracks as much as possible would also help to prevent rainwater from infiltrating the slide mass. Expenditures to accomplish the surface drainage, the sealing of fractures, and monitoring of future movement within colonias El Porvenir and 14 de Febrero would range from $10,000 to $50,000. Recommendations that relate to channel surface waters from the landslide have been described in a previous report by the U. S. Army Corps of Engineers to USAID.

- *(Intermediate to Long Term)* An extensive geotechnical program of sampling, testing, and analysis for the El Reparto landslide similar to that described for the El Berrinche landslide above would cost approximately $150,000. Active construction measures to prevent future movement and stabilize the landslide would be $0.75-to $1.0-million.

- *(Short Term)* Inexpensive measures such as surface drainage and surveying and monitoring of any renewed movement within the head-scarp area of Colonia El Reparto would cost about $5,000 to $15,000.

- *(Short Term)* It is imperative that the Rio Choluteca channel capacity be increased as soon as possible. This is required to ensure free-flowing water through Tegucigalpa for quality of water as well as to restore adequate conveyance or channel capacity for high-water flows. Removal and transport of sediments to higher ground and out of the floodplain should be accomplished. Sediment removed from the channel proper should not be placed in the floodplain areas immediately adjacent to the channel. The low-lying areas adjacent to the channel are important flow-conveyance areas, and should not be filled with spoil materials.

Heavy sediment deposition characterized the flooding in Tegucigalpa.

- *(Intermediate Term)* Consider removal of damaged buildings across from the El Berrinche landslide to increase channel capacity.

- *(Intermediate to Long Term)* Hydrologic and hydraulic modeling of the Tegucigalpa River system should be accomplished. This would allow for determination of design flood flows, corresponding flood profiles through the City, and an early warning flood warning system. With this information, neighborhoods susceptible to flooding can be delineated, flooding