SECTION 10
SUMMARY AND RECOMMENDATIONS

Information on seismic damage to the water systems of Mexico caused by the September 1985 event was compiled and analyzed in this report. All known sources of information were explored and data was used from those considered reliable.

10.1 Summary

The characteristics of the Michoacan earthquakes and the local soil conditions in Mexico City led to widespread damage to the water systems in the metropolitan area. Approximately one third of the 18 million residents of the metropolitan area were without water after the earthquake. There was no observed soil liquefaction or permanent ground displacement in the Mexico City area. Hence the water service disruption is attributed to seismic wave propagation damage to buried pipelines. Other water system components such as tanks, pumping stations and treatment facilities were not significantly damaged.

Most of the damage occurred in segmented piping which comprise the vast majority of the transmission and distribution network. However, the one continuous steel water pipeline in the sytem was also damaged. Damage to this Ciudad Nezahualcoyolt pipeline is unusual in that earthquakes in other parts of the world have apparently not resulted in seismic wave propagation damage to modern continuous steel pipelines. The Ciudad Nezahualcoyolt damage appears to be due to fairly high peak ground velocity, very low soil stiffness and the apparent presence of surface waves in this area of the Valley of Mexico.

In the segmented pipeline, the damage typically occurred at joints due to an inability of the joint to accommodate earthquake induced extension, compression and rotation. These leaks/breaks often occurred near T's, elbows, junction boxes or other hard spots. A possible contributing factor is the subsidence which the metropolitan area has experiences over the past decades. The pipeline deformation due to this subsidence reduced somewhat the ability of

the pipelines to accommodate without failure the earthquake induced deformation. However the ground strain due to subsidence is estimated to be at least an order of magnitude lower than the seismic strain produced by the 1985 event.

In the rush to restore the system after the earthquake, information gathered on leaks/breaks was not as detailed as one would like. Nevertheless, the analysis contained herein indicates that the damage was heaviest in the soft soil areas (ie, Lake Zone) and significantly less in the harder soil areas (ie, Transition Zone and Hill Zone). In the affected zones, the leak/break rate for the primary distribution pipelines (20"ϕ and above) ranged from about 0.2 to 1.5 repairs/km with an average value of about 0.3 repairs/km. Figure 6.25 presents a plot of leak rate versus peak ground velocity.

A buried aqueduct in the southeastern portion of the metropolitan area near Tlahuac suffered significant damage. The damage to this large (72"ϕ) segmented prestressed concrete line can be attributed to large amplitude and the large local variations in ground motion in this valley between two mountains.

Damage was also extensive in smaller diameter piping. One important observation in relation to the smaller diameter piping is the absence of seismic damage to PVC service connections used in the State of Mexico while there were numerous leaks/breaks in the galvanized iron service connections used in the Federal District.

Although the peak ground acceleration in the epicenter region and in the Lake Zone at Mexico City were comparable, the long period frequency content of the Mexico City records lead to peak ground velocity and displacements which were many times larger than those in the epicentral region. As a result, buried pipeline damage in the epicentral region was light compared to that in Mexico City.

10.2 Recommendations

Reducing the seismic vulnerability of an existing water system is a formidable

task. For almost all such systems, replacing the existing elements with ones which have enhanced seismic resistance would be economically impractical. However, the authors feel that the following recommendations are worthy of consideration.

1) All new construction, as well as routine replacements of existing parts of the system, should be made with seismically resistant elements. For buried segmented pipelines, this can be accomplished by using joint details which allows significant axial extension, axial compression and rotation without failure. An alternate approach is to use shorter pipe segment lengths particularly near T's, elbows, valve boxes etc. This would result in more joints per unit length at these critical areas and hence enhanced ability to accommodate seismic deformation without failure.

2) Typical repair items should be stockpiled in an open yard or a earthquake resistant building. This would facilitate rapid repair after an earthquake.

3) An emergency response plan should be prepared. This would include designation of an emergency headquarters as well as an alternate with system maps, establishing a line of command with alternates, purchase emergency communication devices (ie hand-held radios), etc.

4) As part of routine maintenance, shutoff valves should be checked on a regular basis and nonfunctioning valves replaced. This would allow small segments of the system to be isolated after an earthquake, quickly dewatered, and repaired.

5) New forms should be developed so that seismic damage to water systems can be properly documented. This would serve two purposes. First of all, properly documented pipeline damage is needed before a water system in the U.S. can be reimbursed from Federal Emergency Funds. Secondly, detailed information on location and specific damage will allow researchers and water system officials to better understand the problem.