portance, are soil liquefaction and landslips, the intersection of active surface faults and the propagation of ground waves.

Nationally and locally, this study is regarded as a pilot project. There is very little information on damage to vital services, not because it has not occurred but because the information has not been kept.

In assessing the vulnerability of vital services, the types and numbers of elements in the various systems that might be physically affected by a seismic event were established.

Cross-referencing the information graphically and analytically with collateral hazards yielded a scenario containing the principal components and distribution of the various services that might be most affected by a seismic event. The current vulnerability of the mains water system, as theoretically defined, derives from the absolute lack of redundancy - as may be seen from the fact that the system ceases to function when any of its components fails.

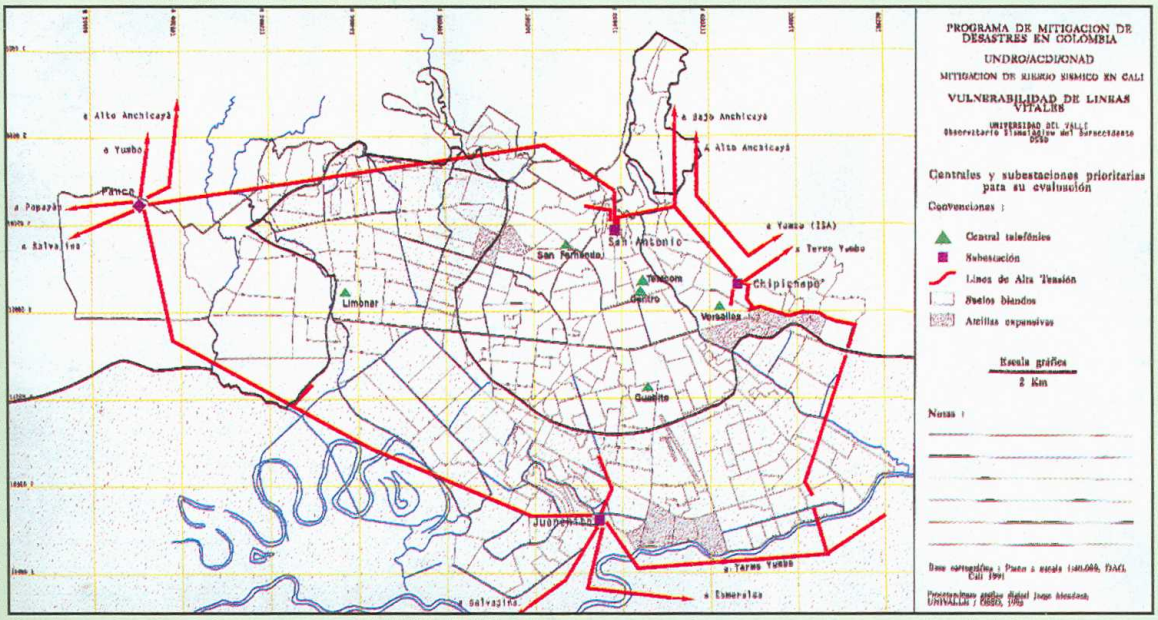
Factors that may affect the removal of run-off and foul water are: faults in the ground supporting the piping system, large landslides causing blockages, and a general power cut putting the pumping stations out of service. This would generate back-ups and flooding, causing pollution and contaminating fresh water if such problems occurred at points where water mains had broken.

Calculation of seismic risk

The scenario of damage to and the operating ability of vital systems after a likely seismic event in Cali shows that there will certainly be breakdowns in every system in the city. The causes may be summarized as follows:

- Within the built-up part of Cali, distant high-magnitude and nearby moderate-magnitude seismic events will be influen-

POWER PLANTS AND SUBSTATIONS WITH AN EVACUATION PRIORITY



tial, and may produce horizontal accelerations of 0.25 g or more in rock. It has been established that soil liquefaction is possible in areas of recent sedimentation with high water tables; there is the potential for distant seismic waves in the high-period range to be amplified in thick layers of soft ground (S3 ground); relative movements may be generated in piping systems owing to changes in rigidity (interfaces between S1, S2 and S3, particularly between S2 and S3); and landslips may occur locally at the edge of the hills to the west of the built-up area.

- The physical vulnerability of the systems is judged to be high, since in most cases systems were designed with no regard for what is now known about hazard parameters or seismically resistant design standards.
- Functional vulnerability is chiefly manifest in the lack of redundancy and flexibility in the systems concerned; if the principal components fail, they may put much of the system out of commission.

It is important to consider the costs of resiting elements and losses occasioned during the time necessary to restore the services affected.

Conclusions

The studies carried out reveal that there is a major concentration of collateral hazards in the eastern zone of the city; it is there that two of the main water distribution plants and piping systems are situated, and it is also the most low-lying part of the city, where the most important collectors and drains of the sewage system are concentrated.

Detailed assessment both of installations, plants and networks and of the ground and structures supporting them must continue, since the more and the better the information available on threats to and the characteristics of the system, the better the assessment will be.

New facilities and installations to replace or improve existing ones should tend to incorporate seismically resistant features and provide systems with greater flexibility and redundancy. Designs should take account of acceptable hazard and risk parameters, exceeding those specified in building codes.

The current studies should be complemented by work on means of mitigation together with contingency plans, since even with good designs and future constructions there will always be a certain degree of vulnerability requiring additional preventive and relief measures if an earthquake should occur.

2. Fine-tuning and supplementing the General Plan for Emergency Response

The National Department for Disaster Prevention and Relief has signed a letter of intent with the Local Emergency Committee for fine-tuning and supplementing the city's General Plan for Emergency Response and advising owners and managers of vital services and installations at risk to consider reducing that risk and take the appropriate action.

The main results have been the following:

- Information (databases, text, inventories, maps) from municipal and private-sector entities, including relief bodies, has been amassed, digitalized and referenced to geographical coordinates in 22 interactive layers with 82 variables. The plan is currently being published by OSSO.
- Local Emergency Committee units now have a digital inventory of resources for disaster prevention and relief.