Earthquake Engineering, Tenth World Conference © 1992 Balkema, Rotterdam. ISBN 90 5410 060 5

Problems and solutions in emergency planning for Western Venezuela oilfields

J.Murria & J.A.Saab
Maraven S.A., Lagunillas, Venezuela

ABSTRACT: Oil production has caused up to 5,3 m. of subsidence in the low laying eastern coast of Lake Maracaibo in Western Venezuela. Coastal protection dikes have continually been built since 1928 to protect life and installations from lake waters. Today these dikes protect 60.000 inhabitants as well as the facilities required to produce or handle 1.5000.000 barrels of oil per day, 60% of the total Venezuelan daily oil production. As western Venezuela is considered a moderate to high seismic area, it was decided investigate the stability of the coastal dikes under seismic loading, paying attention to the liquefaction potential of their foundation soils. These studies have confirmed the possibility of dike failure due to soil liquefaction. Remedial measures are being implemented, and a contingency plan for the eventuality of flooding due to a non-controllable failure of the coastal dikes has been prepared. This paper describes the tasks performed, the problems encountered and the solutions adopted.

1 INTRODUCTION

Oil extraction has produced significant subsidence in the eastern coast of Lake Maracaibo in western Venezuela. This area is known as the Costa Oriental (formerly Bolívar Coast) and extends from Cabimas in the north to Mene Grande in the south and contains some of the oldest and most productive heavy oilfields in the world: Tia Juana, Lagunillas, and Bachaquero (Figure 1). Oil explotation began in 1928. Subsidence was first detected in 1929 in Lagunillas and has been monitored since 1930. Maximum cummulative subsidence has reached 5.3 in Lagunillas with rates as high as 21 cm/year in areas of intensive oil production.

As the original terrain consisted of swamps and lagoons barely above lake level, both coastal and inner (diversion) dikes, as well as an elaborate drainage system had to be built to protect life and installations from lake waters.

These works are collective know as the Costa Oriental Protection System and comprise a total of 47 km of coastal dikes, 59 km inner (diversion) dikes, 490 km of drainage channels, as well as 32 pumping stations with an installed capacity 362.000 m^3/h.

The engineering works of the Costa Oriental Protection System have been designed and constructed on the bases of universally accepted engineering standards. As western Venezuela is considered a moderate to high seismic area, it was decided in 1968 to investigated the stability of the coastal dikes under seismic loading, paying attention to the liquefaction potential of their foundation soils. This decision was prompted by the Niigata and Alaska earthquakes in 1964 and the 1967 Caracas earthquake.

The extensive studies carried out have confirmed the possibility of dike failure due to soil liquefaction of the foundation soils. Remedial measures are being implemented consisting of landside berms and, in some dike sections, compaction piles (Figure 2).

Mitigative measures notwithstanding, and given the number of people living in the subsided areas, as well as the importance that the oil production has for Venezuela, it was decided by the Venezuelan government in 1986 to prepare a contingency plan for the eventuality of flooding due to a non-controllable failure of the coastal dikes.

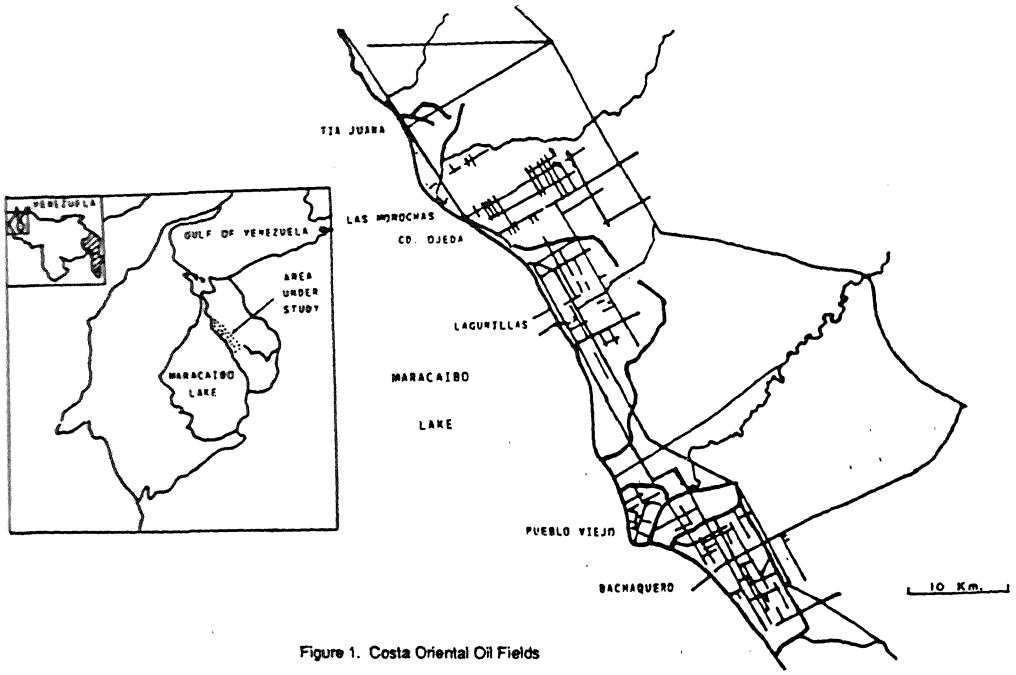


Figure 1. Costa Oriental Oil Fields

2 NEED OF A CONTINGENCY PLAN

As stated above, the implementation of the mitigation measures will increase the return period of the design earthquake from 130 years to 3000 years.

However, and in spite of the considerable increase of safety provided by the mitigative measures, the Venezuelan government, at the request of Petróleos de Venezuela, S.A. decided in 1986 that a contingency plan had to be prepared for the eventuallity of flooding of the areas below lake level resulting from a non controllable failure of the coastal dikes.

This decision was prompted by the importance that the Costa Oriental region has for Venezuela:

- More than 60.000 people live in areas below lake level.
- About 1.500.000 barrels of oil per day are either produced in or handled through the oil industry facilities installed in the subsided areas.
- The high replacement value of these facilities and the loss of production during replacement.

As can be easily understood, a dike breach and the consequent flooding would be a disaster of incalculable consequences for Venezuela.

3 PREPARATION OF THE CONTINGENCY (PLAN COLM)

The proposal for the preparation of the contingency plan was approved by the President of the Republic in 1986.

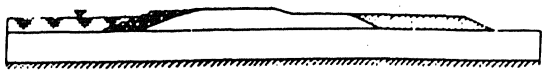
The contingency plan is know as PLAN COLM, "COLM" being the acronym in Spanish for Costa Oriental del Lago de Maracaibo. A multidisciplinary group was established in 1986 under the supervision of Maraven. The "final" version of the contingency plan was distributed among the interesed parties in January 1991, but updating and enriching of the plan is still in progress and will continue in the future. The philosophy of the preparation of the Plan COLM has always been that the plan is not and end in itself: it should be viewed as a tool for appopiate contingency planning.

The contingency plan was prepared on the basis the following conceptual scheme:

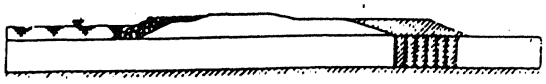
- Definition of the affected areas.
- Collection and analysis of basic information
  - Cartography
  - Inventory of industrial facilities and services infrastructure
  - Census and population surveys
- Analysis of scenarios
- Impact evaluation
- Strategy for information to the population
- Evacuation plans
- Training

- Educational aspects
- Simulations and exercises, both desktop and field
- Review and updating
- Incorporation of the latest technological advances (data bases, geographic information systems, expert systems, etc)

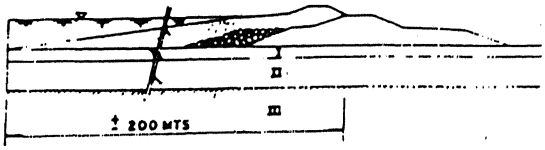
It is not the aim of this paper to give a detailed description of the process of preparation of the Plan, nor to describe in detail its contents, but rather to highlight the most salient aspects, to identify the main problems encountered during its preparation and to summarize the "solutions" adopted.



DOWNSTREAM BERM



DOWNSTREAM BERM WITH SOIL IMPROVEMENT



ARTIFICIAL BEACH

FIG. 2. MITIGATIVE MEASURES

Definition of the affected areas

For the purpose of the preparation of the contingency plan, the affected area was limited, along the Costa Oriental, by Cabimas to the North, Mene Grande to the South and the Lara-Zulia highway to the East (Figure 1).

Collection and analysis of basic information

An inventory of facilities and resources was prepared paying special attetion to their location, inside or outside the floodable area. This is important because a facility (a school, a hospital, a church) outside the floodable area is a very valuable resource for the handling of the emergency whereas the same facility inside the floodable area becomes a liability in the sense that special measures and precautions area to be taken for its evacuation of its. inhabitants.

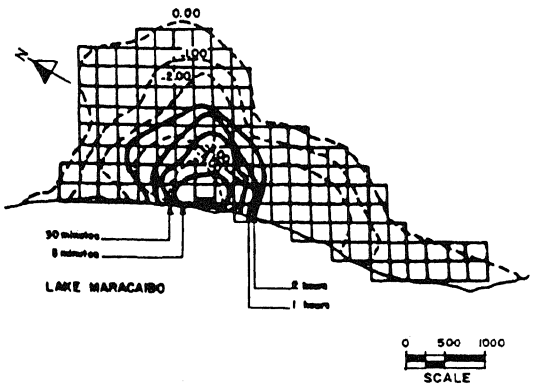


Figure 3. Progression of the flooding wave, Tia Juana, Case TIATC

The information gathered has been drawn in a series of maps and recorded in a computerized data base.

Analysis of scenarios

The number of probable simultaneous dike failures and their most probable location along the coastal dikes was analyzed.

To complete the analysis of scenarios, INTEVEP, the research and development company of Petroleos de Venezuela, was asked to develop a mathematical model to evaluate the mode and progression of the flooding wave (INTEVEP, 1989).

Figure 3 shows the progression of the flooding wave for a progressive (1 hour) dike breach, 250 m. wide, located in the center of the Tia Juana dike. Similar figures were prepared for Lagunillas and Bachaquero.

Organitation

In May 24, 1990, the Venezuelan President issued decree Nº 908 creating the "Permanent Presidential Commission for the Preparation and Execution of the Contingency Plan for Flooding Risk of the Eastern Coast of Lake Maracaibo", with representatives of the Ministries of Interior Relations, Defense Transport and Communications, Environment, Urban Development, and Energy and Mines, as well as representatives of the Governor of the State of Zulia, of the Corporation for the Development of the Zulia Region and Maraven, S.A., the later holding the Presidency. Representatives of the Ministries of Health and Welfare and Education were added in July, 1991. The headquarters of the Commission are to be in Ciudad Ojeda which is above Lake Level.

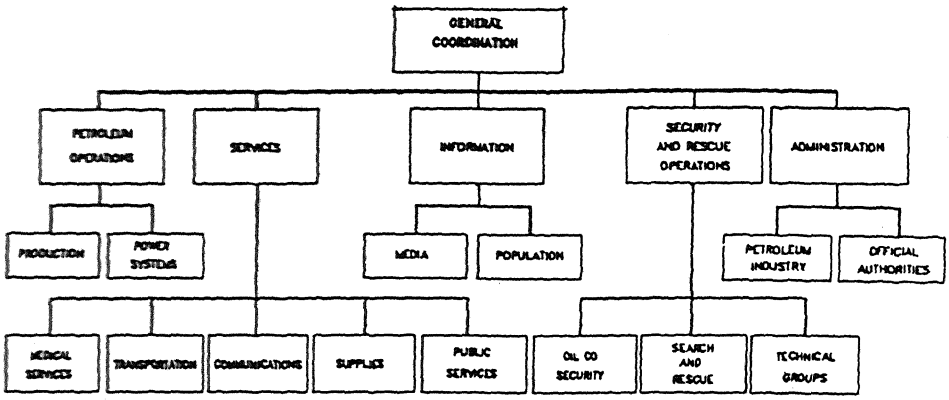


FIGURE 4. PLAN COLM. ORGANIZATION CHART

The presidential decree also states that the General Coordinator will be appointed by Maraven and will be charged with finalizing, maintaining, updating, and perfecting the plan.

In case of the occurrence of the emergency, the general coodination of the contingency plan will be automatically transferred to the Governor of the State of Zulia who, in turn, could transfer it to the Commanding Officer of the Region 2 Military Command. Figure 4 shows the first three levels of the organitation chart for the personnel involved in the handling of the emergency.

Detailed organization charts have been prepared showing the line of command and communication for the more than 650 persons involved. These include oil industry personnel, armed forces, government officials and specialized personnel.

Inforamtion to the public

One of the main obstacles - if not the main obstacle - encountered in the preparation of the contingency plan, has been the reluctance (or plain refusal) on the part of some highly placed officials and decision makers to inform the people living in the critical areas of the existance of the contingency plan. This reluctance is, of course, coupled with the refusal to accept the necessity of contingency planning in the first place. More than one highly placed official, having reluctantly accepted the need of preparing a contingency plan for the Costa Oriental, have insisted that there was no need to inform the public because this would create panic!!!

This opposition has been finally overcome and, at the time of this writting, a highly qualified local ad agency has been retained to prepare an information campaing that will include TV, radio, newspapers ads and meetings and presentations to the public. Involvement of local community leaders constitutes one of the pivotal considerations of the information strategy.

It is expected that the campaign can be in the second half of 1992.

4 SHORTCOMINGS AND DRAWBACKS ENCOUNTERED

These can be summarized as follows:

- Lack of understanding among elected officials, politicians and decision makers of the need to prepare a contingency plan in the first place.
- Difficulty in coordinating the activities of such diverse groups as central, state and municipal governments, and oil company executives.
- Need to continually motivate the people involved in the preparation of the plan.

The results so far have shown, that, in spite of the above, it is possible to get people interested and motivated once they have been convinced of the need of contingency planning.

CONCLUSIONS

This paper has attempted to give an overview of the Coastal Protection System, the mitigative measures being implemented, and the contingency plan being prepared.

The following conclusions can be drawn:

- The mitigative measures being implemented will bring the safety factor of the Coastal Protection System to an internationally accepted level.

The Contingency Plan, once finalized in its details and properly exercised, will minimize human and material damage in case of the unlikely event of a dike breach and the consequent flooding.

REFERENCES

Abi-Saab Soto J., Roest, P.W., Velsink, H. "Polders and Dykes of the Bolivar Coast, Venezuela". Int Symp. on Polders of the World, October 1982, Netherlands, Vol. I, pp. 134-135.

Abi-Saab Soto J. and Murria J. "Origen y desarrollo del sistema de protección costanera, Costa Oriental del Lago de Maracaibo". I Jornadas de Tecnología Producción, INTEVEP, Los Teques,Venezuela 1985.

INTEVEP, S.A. "Simulación de los patrones de inundación por rotura de los diques de la COLM", Technical report Nº INT 01968-88, December, 1988.

Murria, J. and Abi Saab J. "Engineering and construction in areas subjected to subsidence due to oil production". 5th International (FIG) Symposium on Deformation Measurements and 5th Canadian Symposium on Mining Surveying and Rock Deformation Measurements, Fredericton, N.B., Canada, 1988, pp. 367-373.

NEDECO, The Hague, The Netherlands. "Bolivar Coast dykes, Venezuela, General Report to C.S.V., March 1968.

Nuñez, O. and Escojido, D. "Subsidence in the Bolivar Coast", Publication Nº 121 of the International Association of Hydrological Sciences, Proceedings of the Anaheim Symposium, December 1976, pp. 257-266.