

## Effects of Marikina Faults on groundwater

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**Abstract:** Metro Manila faces a major shortage problem that will necessitate the development of all possible sources. Structural geological study is an effective tool in maximizing the exploration of water resources. The Marikina Faults, a permeable zone which could facilitate the movement and occurrence of groundwater should be fully evaluated for such purpose.

The main objectives of this paper are 1) to study the effects of geology particularly the Marikina Faults on groundwater, 2) to evaluate the groundwater resources of the Marikina Valley area, and 3) to assist urban planners in the identification and assessment of geologically favorable sites for groundwater development.

The Marikina Fault zone is composed of several geologic structures in the Marikina Valley at the eastern edge of Greater Manila Area (GMA). Geological studies indicate that the study area is controlled by two fault systems: the East and the West Marikina Valley Faults. Movements along these structures strongly influenced the morphology and groundwater conditions in the study area.

Hydrogeological studies show that the groundwater is confined in the Pleistocene Guadalupe Formation, Quaternary Alluvium and along the fault zones.

Geochemical data indicate that there are two types of groundwater (calcium bicarbonate and sodium-rich waters) within the Guadalupe Formation west of the West Marikina Valley Fault, and three types of groundwater (calcium bicarbonate, sodium-rich and sodium chloride-rich waters) within the Marikina Valley.

The Marikina Faults facilitate the movement and circulation of groundwater. These have adverse effects, however, on groundwater quality as seepage of contaminated water is enhanced.

### INTRODUCTION

The water shortage problem of Metro Manila demands that all possible sources should be studied, analyzed and developed for optimum utilization. Groundwater is a primary concern because it is the most economical source of water supply. The main objectives of this paper are 1) to study the effects of geology particularly the Marikina Faults on groundwater, 2) to evaluate the groundwater resources of the Marikina Valley area, and 3) to assist urban planners in the identification and assessment of geologically favorable sites for groundwater development.

Three lithologic units are present in the local mapping area. These units consist of the Upper Miocene Alagao Volcanics, Pleistocene Guadalupe Formation, and Quaternary Alluvium (Fig. 1). The Marikina Fault zone (Fig. 2), is a group of major geologic structures in the Greater Manila Area (GMA) which controls the morphology of the Marikina Valley and the course of the Marikina River from Montalban in the north to Pasig in the south. Several secondary faults or fracture systems can be observed traversing the main faults. In the mapped area (Fig. 3), the Marikina Fault zone consists of several parallel faults the most

predominant are the two normal faults, the West Marikina Valley Fault (WMVF) and the East Marikina Valley Fault (EMVF).

The WMVF is a continuous structure which can be traced from the north in the vicinity of Montalban to the town of Pasig in the south. In contrast, the EMVF is discontinuous in the southern part of the valley (Marikina-Pasig). The existence of geological structures such as the Marikina Faults may have varying influences on groundwater flow direction, quality and aquifer characteristics (Faisal, 1989; Quiazon, 1976; Arcilla *et al.*, 1983).

### EFFECTS OF THE MARIKINA FAULTS ON THE GROUNDWATER RESOURCES OF THE STUDY AREA

The Marikina Faults have major effects on the distribution and circulation of groundwater within the study area.

#### Effects on Aquifers

Normal movement along the Marikina Faults resulted in the development of an east-facing escarpment and relatively flat Marikina Valley in the downthrown block. This movement has

profound effects on the aquifers. Semi-confined to confined aquifers were created in the upthrown blocks and unconfined to semi-confined types in the downthrown blocks. The aquifers were displaced by the fault movement affecting their continuities and separating them into several aquifers of limited areal extent. Faulting also resulted in abrupt differences in the topography and elevation leading to the formation of new aquifers.

**Effect on the Water Table**

The water table is rarely horizontal in unconfined conditions. It usually follows roughly the topography and is distinctly inclined towards

depressions under the influence of gravity.

In the study area, the water table follows the configuration of the topography and such theory is applicable to groundwater movement from east and west towards Marikina Valley. For the case of confined aquifers, the piezometric level is controlled by hydrostatic pressures and does not follow the topographic configuration because the piezometric situation depends on the compression pressure.

**Effects on Recharge to Aquifers**

The depths, thickness and aquifer types are variable within the area and are affected by both stratigraphic and structural parameters.

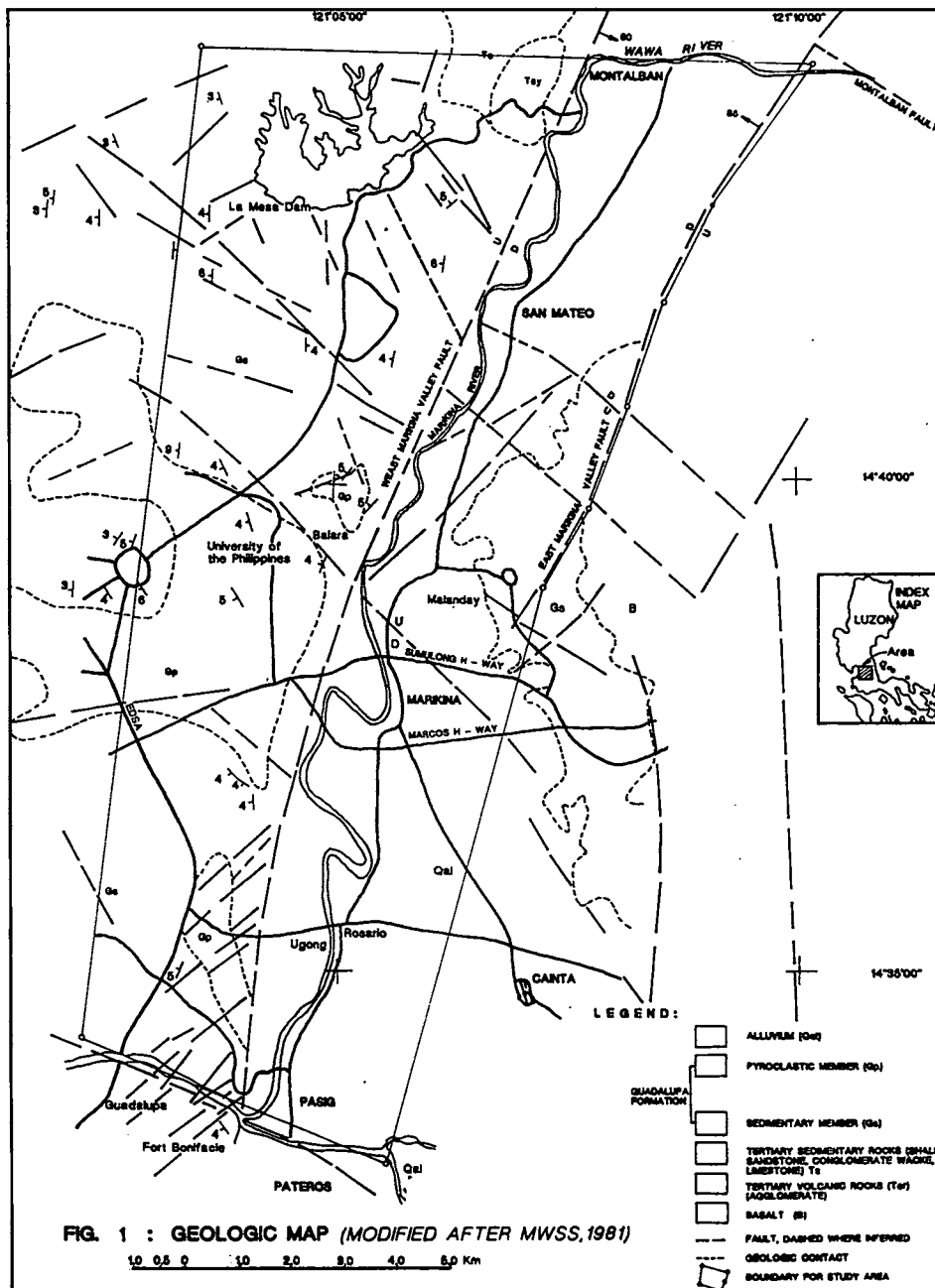


FIG. 1 : GEOLOGIC MAP (MODIFIED AFTER MWSS, 1981)

Figure 1. Location stratigraphic column.

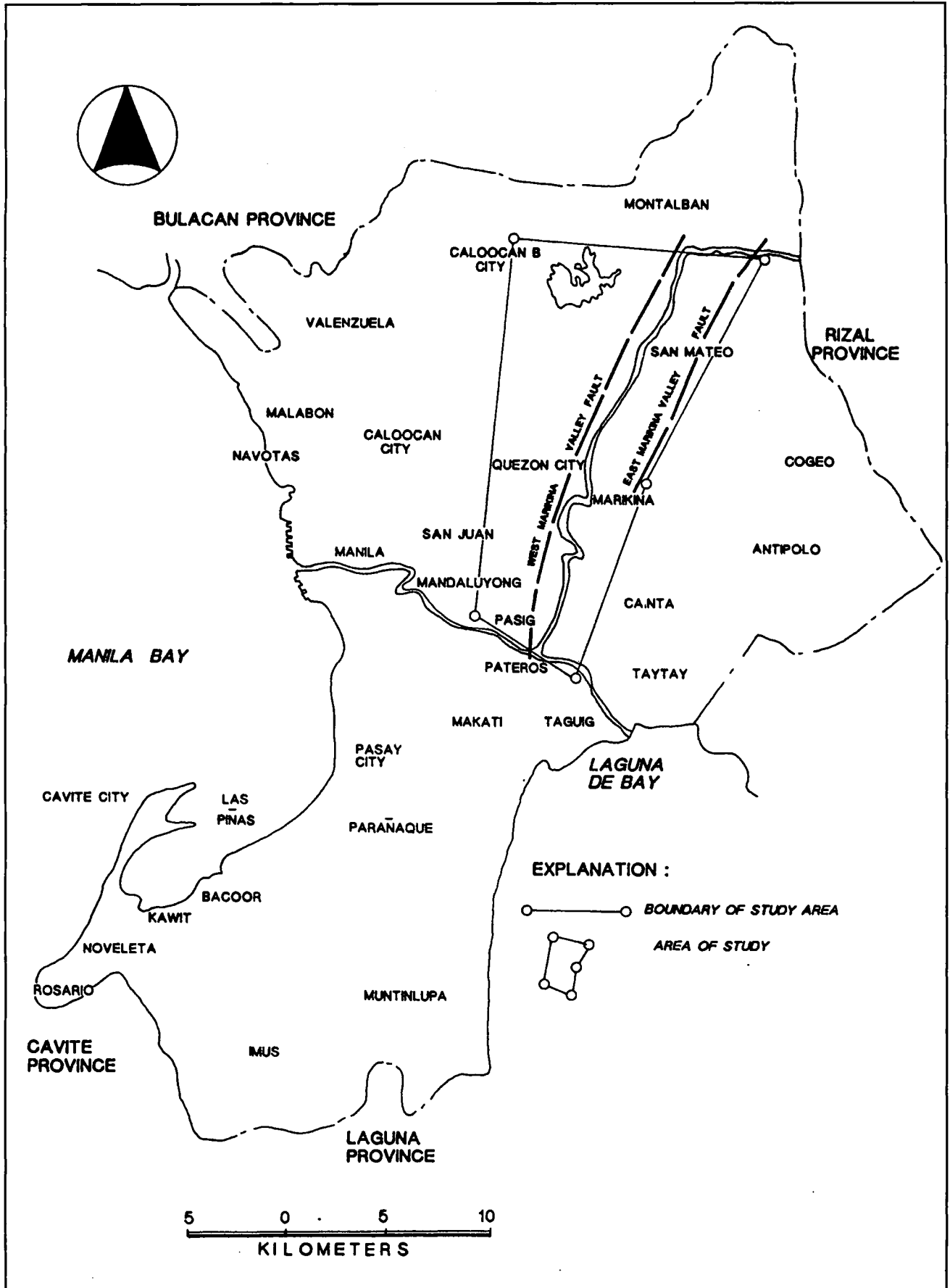


Figure 2. Geological map.

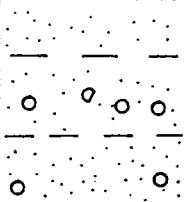
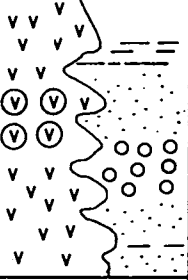
AGE	COLUMN	THICK- NESS (m)	NAME	DESCRIPTION
QUATERNARY				ALLUVIAL AND MARINE DEPOSITS UN- CONSOLIDATED GRAVEL, SILT & CLAY
PLEISTOCENE		1,300 - 2,000	GUADALUPE FORMATION	PYROCLASTICS - ANDESITIC AGGLO- MERATE, LAPILLI TUFF, TUFF  SEDIMENTARY - TUFFACEOUS CON- GLOMERATE, SANDSTONE, SILTSTONE
			ALAT CONGLO- MERATE	NO EXISTING DATA IN STUDY AREA
PLIOCENE				
MIOCENE	LATE			
	MIDDLE	~	MADLUM FM. ALAGAO VOLCANICS	BASALTIC AGGLOMERATE-VARIC- COLORED CLASTS OF PYROXENE BASALT PORPHYRY, TUFF HORNBLLENDE DACITE, CHERT

Figure 3. Location of study area.

Interfingering and intertonguing relationships between the impermeable argillaceous and permeable sandstone and gravelly lithologic units produce confined and semi-confined hydrologic conditions in Guadalupe Formation and the Quaternary Alluvium, respectively. On the other hand, movements along the Marikina Fault not only resulted in displacements of aquifers but more significantly fractures the rocks. The resultant secondary permeability controls run-off, increases rainwater infiltration subsequently creating new productive aquifers.

One of the recharge sources of the aquifers in the study area is the leakage from the La Mesa Reservoir. This leakage is manifested by seepages observed during field investigations and is now the object of investigations of the Manila Waterworks and Sewerage System. This leakage, more likely the product of fracture systems related to the Marikina Fault, will increase groundwater infiltration and serve as a recharge to the aquifers abutting the fault zone.

The Marikina Fault produced an aquifer system within the Guadalupe Formation and Quaternary Alluvium which became the source of groundwater in the study area (Sandoval and Mamaril, 1970; Schoell *et al.*, 1985).

### **Effect on Water Quality**

The present geochemical studies indicate two types of groundwater within the Guadalupe Formation west of the WMVF and three types within the Marikina Valley. These groundwater types consist of calcium bicarbonate and sodium-rich in Guadalupe Formation and calcium bicarbonate, sodium-rich and sodium-chloride rich types in the Marikina Valley.

Sodium-rich waters were also detected in the eastern and western blocks of the WMVF and within the fault zones. Higher values in the fault zones may be attributed to the effects of recharge from the sodium-rich sedimentary unit of the Guadalupe Formation and or from contamination of polluted water.

Analytical results of groundwater samples (Figs. 4 and 5) also indicate marked chemical composition differences in the eastern and western blocks of the WMVF. The western fault block has relatively high iron, magnesium, nitrate and zinc concentrations while the eastern block is high in bicarbonate, chloride, sodium, potassium and calcium contents. These variations may be correlated to the differences in the underlying lithologies of the Guadalupe Formation and the Quaternary Alluvium in the western and eastern blocks, respectively. The contact of these lithologic units is fault-controlled. The high bicarbonate levels

within Quaternary Alluvium may also explained by its proximity to the recharge area in the east. The high sodium and chloride contents may have resulted from the periodical seawater admixture with the Pasig River waters during the normal tidal fluctuations and found its way within the alluvial deposits.

Recent geophysical, geochemical and hydrogeological studies indicate the presence of contaminated water, specifically in deep groundwater depression zones in Marikina and Pasig. The presence of this contamination is probably facilitated by the Marikina Faults which serve as conduits for water movement from different host rocks towards the depression zones. The Marikina Faults may also serve as a direct agent in groundwater natural pollution. An example is the Taiaugco property in Quezon City which receives 480 tons of solid waste daily, and is the second biggest dumpsite in Metro Manila. This area is located about 4 km from the La Mesa Reservoir. Even in the absence of environmental impact studies on the dumpsite situation, groundwater pollution is inevitable since the downward movement and circulation of contaminated surface water and shallow groundwater will be enhanced by the secondary permeability related to the Marikina Faults.

### **Effect on Direction of Groundwater Flow**

The general direction of groundwater movement is from east to west which is the main source of groundwater recharge of the Marikina Valley and from north to south in the uplifted block (Guadalupe Formation). However, the presence of the WMVF-controlled Marikina River serves as a conduit for groundwater flow and facilitates new west-east flow direction and north-south direction to discharge into the depression zones (Figs. 6, 7, and 8). In such cases, the Marikina Valley Fault system may also serve as channels for the movement of contaminated water from the south if there is a continuous decline in the water level caused by the heavy extraction of groundwater. Utilizing the same fault system in the future or artificial recharge for the aquifers, a rise in water level will be achieved. In general, the Marikina Fault system has favorable effects on the current and future groundwater resources of the area. It enhances rather than impedes groundwater circulation and storage.

## **CONCLUSIONS**

Based on the available information obtained from intensive field and laboratory investigations, conclusions on the effects of the Marikina Valley Fault system on groundwater conditions of the study

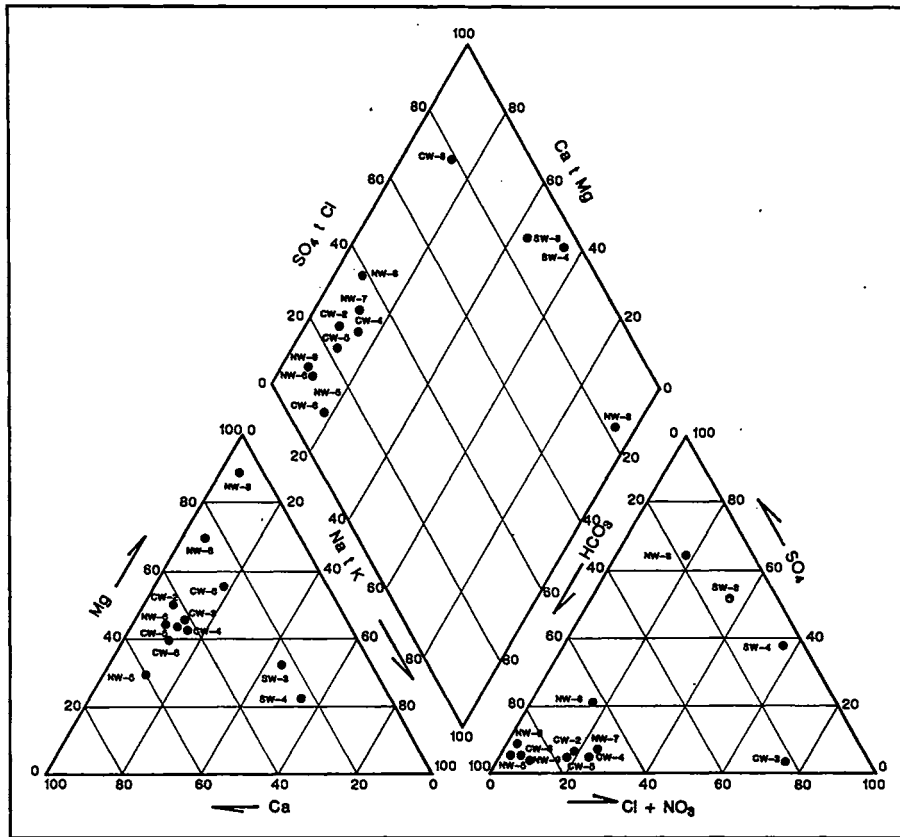


Figure 4. Chemical analysis of water from western block of WMVF wells plotted on a piper trilinear diagram.

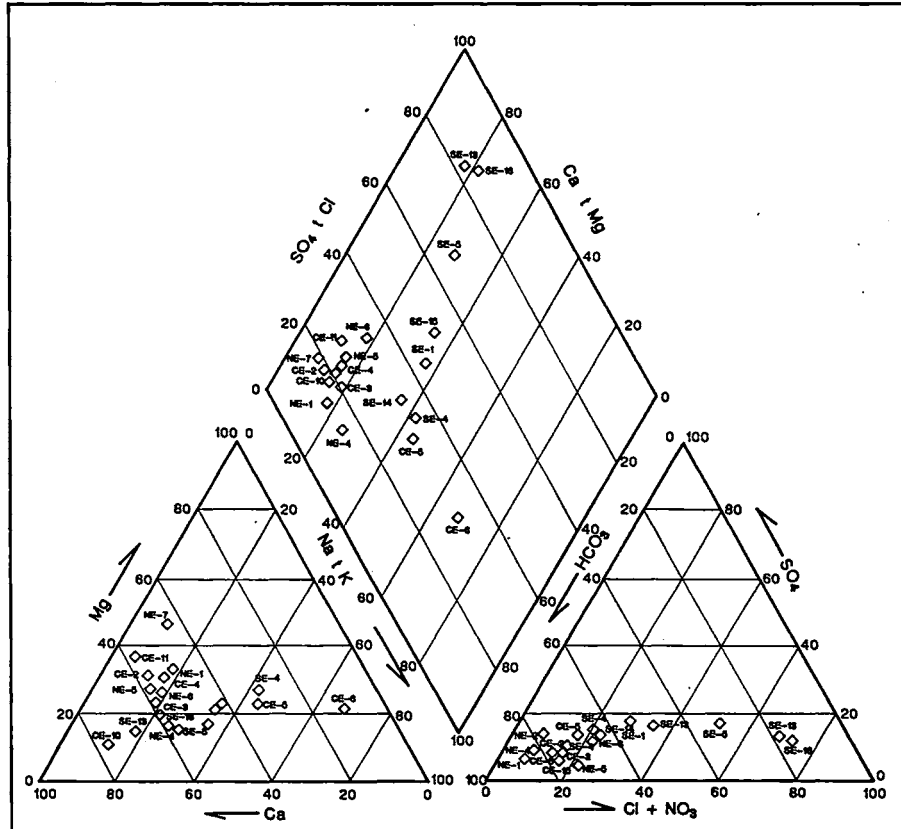


Figure 5. Chemical analysis of water from eastern block of WMVF wells plotted on a piper trilinear diagram.

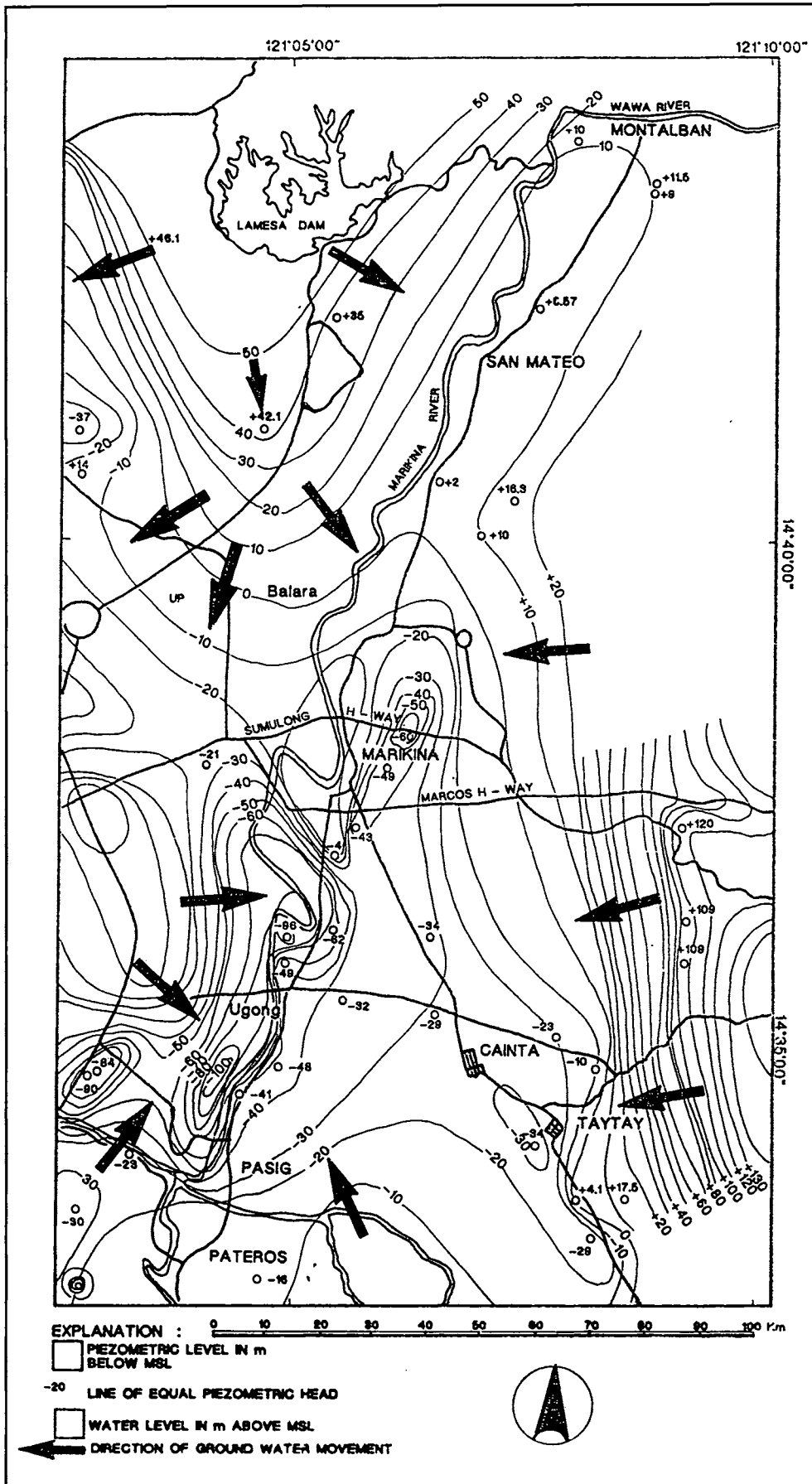


Figure 6. Piezometric surface of aquifer system in Metro Manila.

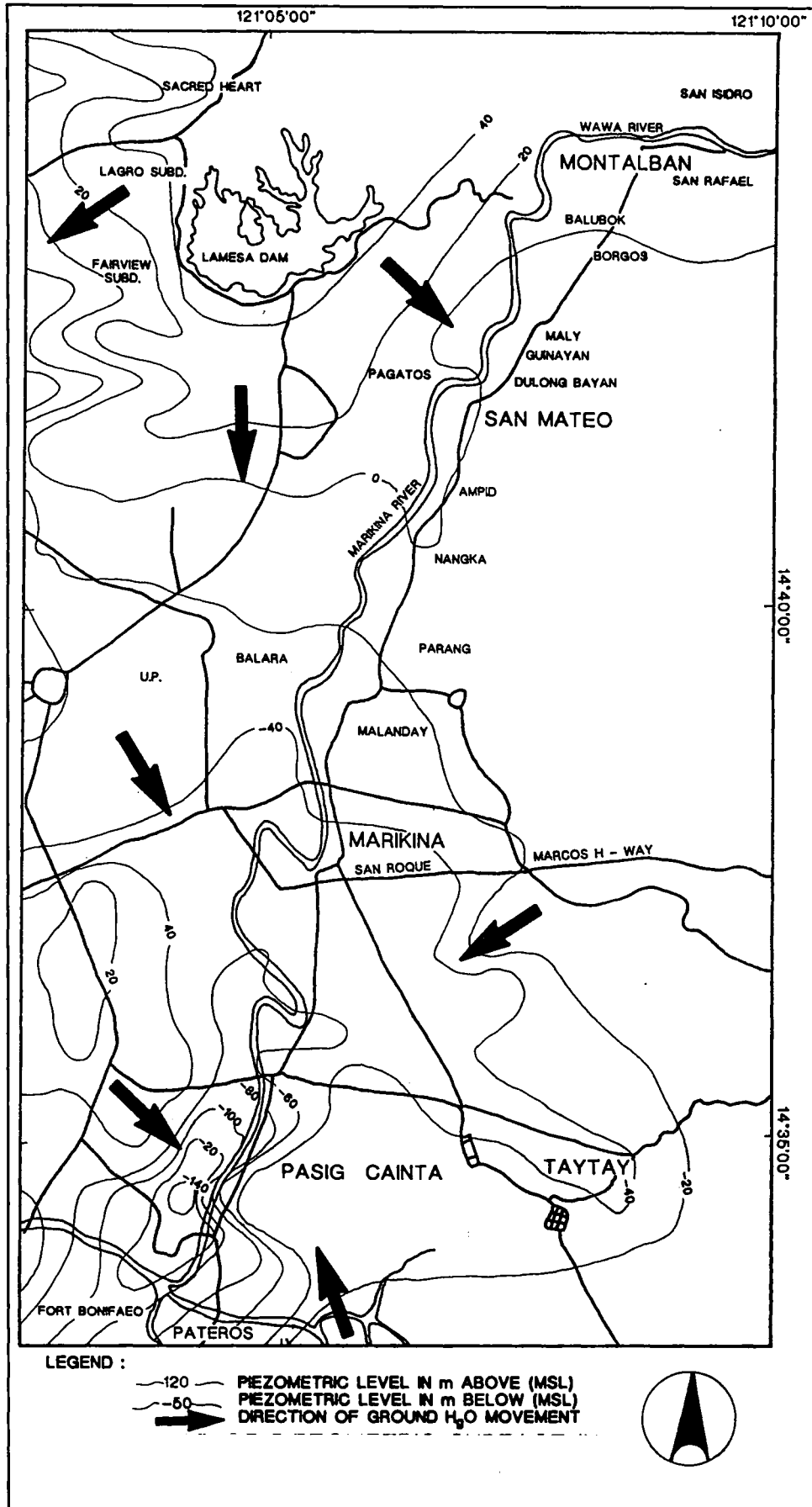


Figure 7. Map of piezometric surface in Manila bay aquifer system, greater Manila area.



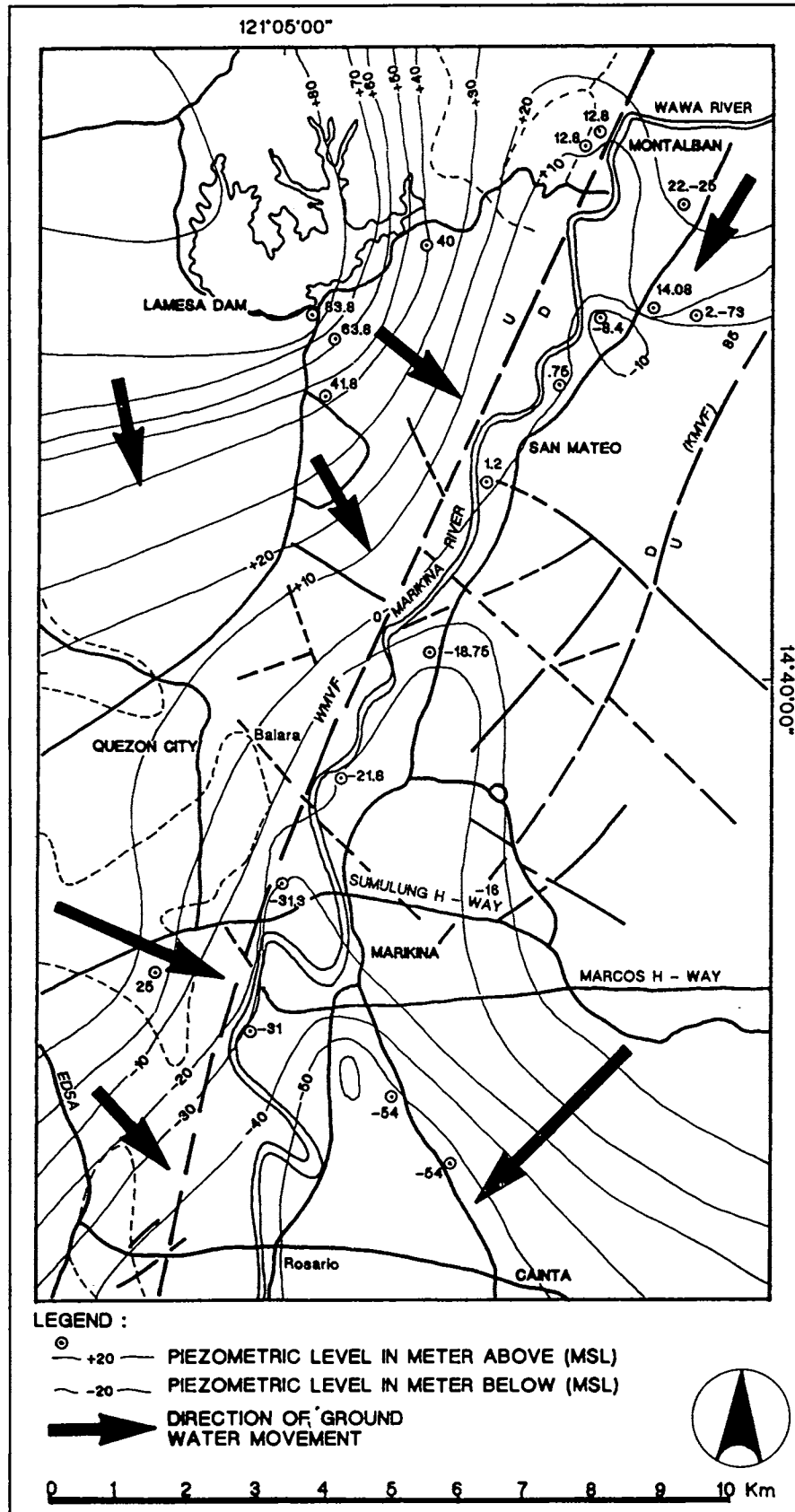


Figure 8. Piezometric surface of aquifer system in segment along Marikina Fault from Pasig to Montalban.

area are as follows:

1. The Marikina Faults are not barriers but rather facilitate the movement and circulation of groundwater.
2. These affected the continuity of aquifers, as well as increased the permeability and storage capacity of the rock formations.
3. These may be tapped to supplement future groundwater requirements of Greater Manila particularly in areas where the faults intersect the rivers.
4. These have adverse effects, however, on groundwater quality as seepage of contaminated water is enhanced.

## RECOMMENDATIONS

Recommendations are classified into four categories according to the nature of investigations required.

### Further Exploration

1. In as much as the present study covered the northern segment of Marikina Faults from Pasig to Montalban, future investigations should be conducted in the southern portion from Pasig to Laguna de Bay to observe its structural behavior and correlate it with the present data.
2. Detailed seismic monitoring should be done in the area along Marikina Faults to enable detection of any seismic activity along the fault zone.

### Patterns of Groundwater Exploration

1. Areas of noticeable decline in water table and accompanying deep depression should be located within the Greater Manila Area.
2. Wells should only be recommended if the formation is strong enough for well development.

## Groundwater Pollution

1. All future well constructions in areas of high contamination should have good well spacing and design. This may be accomplished by proper investigations of existing pumpage and pumpage zone.
2. Detailed hydrogeological studies in the Taiagco property and waste dump area in Quezon City should be done to detect any contamination of groundwater and mitigate the situation.

## Future Groundwater Development

Wells proposed within the study area should be located within the following zones:

1. Along or within the Marikina Faults and complimentary structures particularly in the area where the structures intersect the Marikina River. Such setting permits a direct recharge of the aquifers from the Marikina River via the permeable faulted zone.
2. The northern portion of the study area due to the availability of thick permeable layers of coarse-grained sand and gravel of Quaternary deposits as aquifers.

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