THE STUDY
ON SUSTAINABLE GROUNDWATER DEVELOPMENT
FOR BOGOTA PLAIN
IN THE REPUBLIC OF COLOMBIA

FINAL REPORT
SUPPORTING REPORT

PART 9

PILOT PROJECT FOR

ARTIFICIAL GROUNDWATER RECHARGE

Final Report
(Supporting Report)

Part 9 Pilot Study For Artificial Groundwater Recharge

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PART - 9 PILOT STUDY FOR ARTIFICIAL GROUNDWATER RECHARGE

By storing the surplus surface water artificially into the ground, it becomes possible to make reservoir in the under ground and use groundwater stored in it. It enables to develop and conserve groundwater resource at the same time. Pilot Study for artificial recharge shall be implemented by actually injecting water into a well to make clear of possibility and problem of the artificial recharge, and to get basic information to formulate a plan of artificial recharge project

CHAPTER 1 Pilot Study Site

JICA Study Team proposed four sites for Pilot Study for artificial recharge in Phase-I of the Study.

① Vitelma
② La Aguadora
③ La Salle
④ Subachoque

Sites of ①～③ are located in the foot of the Eastern Hills. On the other hand, ④ Subachoque site is located on Quaternary in the western part of Bogota Plain. Target of artificial recharge in site ①～③ is Cretaceous Formation and Quaternary in site ④. Both of Cretaceous and Quaternary is important for target of the artificial recharge. However, It seems that Cretaceous is more important than Quaternary for artificial recharge. Therefore, Pilot Study for artificial recharge to Cretaceous Formation is implemented in this Study. The reasons why sites ①～③ were proposed for Pilot study site are listed below:

- Site ①～③ are located in the foot of the Eastern Hills where Cretaceous Formation is distributed.
- Site ①～③ are located near mountain streams, where it is easy to get recharge water.
- Site ①～③ are located in EAAB yard. There is no problem in land acquisition.

From the proposed site of ①～③, ①Vitelma site was finally selected for site for Pilot Study. The reason is explained below:

- San Cristobal River flows near Vitelma site, where it is possible to get enough water during the Pilot Study period.
- There is a siltation pond of EAAB in Vitelma site. Therefore, it is easy to get clean water for Pilot Study.
- As flowing well of La Salle site shows, the area of the altitude of 2,600m like La Salle site is not suitable for implementation of Pilot Study because of possibility of flowing well. On the contrary, Vitelma site is located at the altitude of 2,800m. It seems no possibility of flowing well and suitable for Pilot Study.

Procedure of the Pilot Study (artificial recharge test) is as follows.

1.1 Recharge and Monitoring Well

EAAB drilled two wells in Vitelma site, one well for artificial recharge and the other for observation. Geological condition of wells are shown in Table-1.1.

Table-1.1 Geological Condition of Vitelma Well

Well	Depth (m)	Diameter	S.W.L.	Geology	Depth	Rock face
Recharge well	300m	8 inch	GL-6.63m	Colluvial	0-22	Gravel, sand, silt
				Labor・Tierna	22-180	Sandstone dominant alternation
				Chipaque	180-30	Shale
monitoring well	240m	4 inch	GL－6.84m	Colluvial	0-36	Gravel, sand, silt
				Labor ・	36-188	Sandstone dominant alternation
				Chipaque	188-24	Shale

Note) S.W.L. of monitoring well is from ground level of recharge well.

According to pumping test in Vitelma wells, specific capacity of recharge well is 62m2/day, which shows high production capacity of this well. Distance between two wells is 120m and influence of pumping of recharge well was observed in monitoring well within only 15 minutes after pumping stated. This result shows that response between wells of Cretaceous aquifer is vary fast because of highly confined state of Cretaceous aquifer. From this, it is expected that effect of artificial recharge will travel fast toward surrounding wells.

1.2 Procedure of Pilot Study

Procedure of the Pilot Study (artificial recharge test) is as follows.

- In the Pilot study, possible recharge rate into the recharge well was evaluated, and influence of artificial recharge on surrounding aquifer was observed by the observation well. The distance between recharge well and observation well is about 150m.
- Water pumped up from the settling pond was injected into the recharge well. Concrete tank with volume of 400m^3 was constructed near the recharge well, and pumped water was conveyed into the concrete tank. The tank and the recharge well were connected by pipe, and water inside the tank entered into the recharge well with gravity. Then recharged water infiltrated into the deep aquifer through screen of the well. Design of tank and recharge system is shown in Figure-1.1
- Recharge rate was measured by observing water draw-down inside the concrete tank. At the same time, recharge rate was measured by flow-meter installed to pipe which connects concrete tank and recharge well. Cycle of observation is shown in Figure-3.2.
- La Salle well and Suba well, which were drilled by EAAB, are located in the Eastern Hills and have the same aquifer as Vitelma site. Comparing specific capacity of these wells with Vitelma well, result of Pilot Study can be applied to above two sites.
- Influence of the artificial recharge on surrounding aquifer must be investigated by observing groundwater level of the observation well. Therefore, screen of the observation was installed for the same aquifer as recharge well.
- It was anticipated that recharge rate would decrease with time. Decrease of recharge rate was judged by speed of water level drawdown in concrete tank.
- When the recharge rate decreased to same extent, water recharge was stopped. Then a pump was installed into the recharge well to conduct pumping test. By the pumping test, silt clogging the recharge was removed. The pumping test continued for 1 to 7 days. After the pumping test, water recharge test started again.

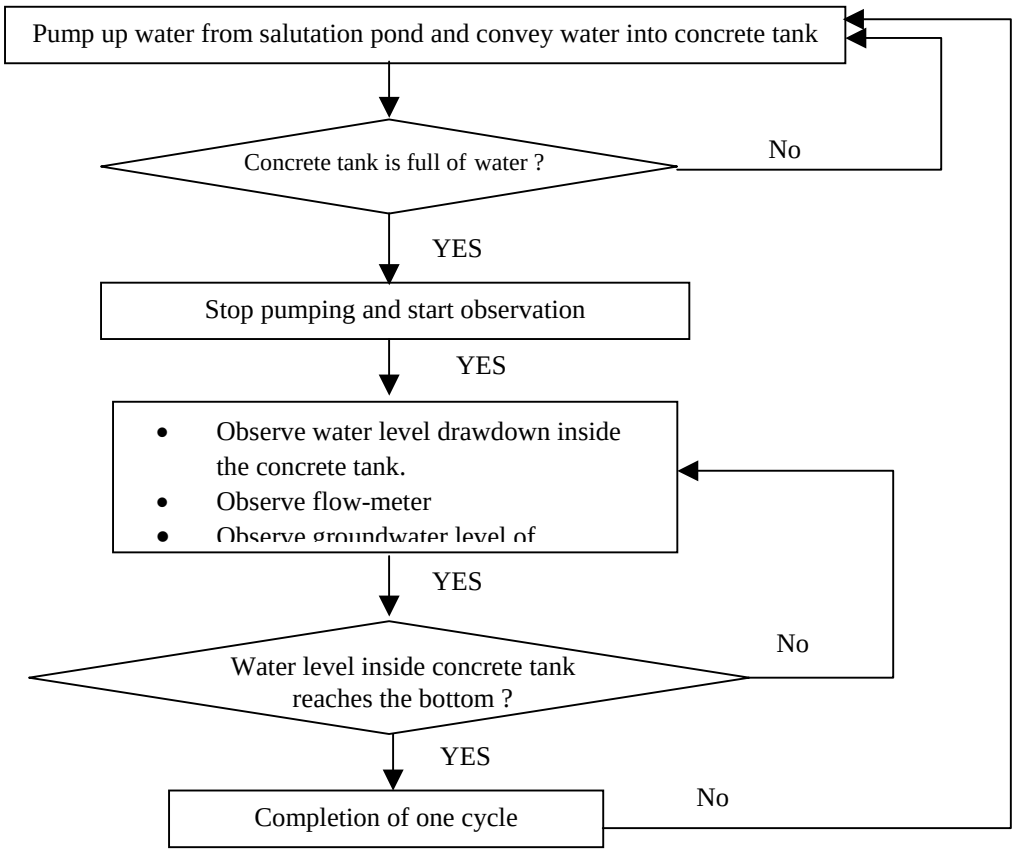

Figure-1.1 Observation Cycle of Pilot Study

1.3 Attention to be made in Construction of Facilities for Pilot Study

- Concrete tank was covered with roof to prevent plants from entering the pit. Plants in the recharge water cause bacteria that grows covering screen of well and aquifer around the screen. It results in decrease of recharge rate.
- Well screen was installed on the bottom of the concrete tank, and water in concrete tank flowed into the screen. River water becomed clean inside siltation pond, and then this water was conveyed into concrete tank. In addition to settling pond, screen inside concrete tank removed silts in water again to make water cleaner.

CHAPTER 2 Recharge Test Result

One example of result of Pilot Study is shown in Figure-3.2. Figure-3.2 shows fluctuation of groundwater level inside recharge well during water injection, from16th to 26th Nov. 2002. This result is summarized in Table-2.1.

Table-2.1 Result of Artificial Recharge

Injection rate	Pressure head of injection	Specific injection	Specific capacity in Pumping Test
864 m^3/day	8.41 m	103 m^2/day	69 m^2/day (pumping rate1,296 m^3/day)

CHAPTER 3 Consideration on Recharge Test Results

Efficiency of artificial recharge is judged from specific injection (=injection rate/increase of groundwater level of well). Specific injection has almost same meaning of specific capacity, the former shows capacity of injection, the latter shows capacity of pumping. Specific injection will decrease as injection rate increase. Specific injection of 103m^2/day in Table-1 is for injection rate of 864m^2/day. From Pilot Study, it was proved that value of specific injection is more than that of specific capacity of pumping test.

It is expected that efficiency of artificial recharge will decrease as injection continues. Injection rate is so far gradually decreasing from 1,300 to 864m^3/day. It is due to clogging of aquifer surrounding recharge well. However, injection rate will recover by pumping.

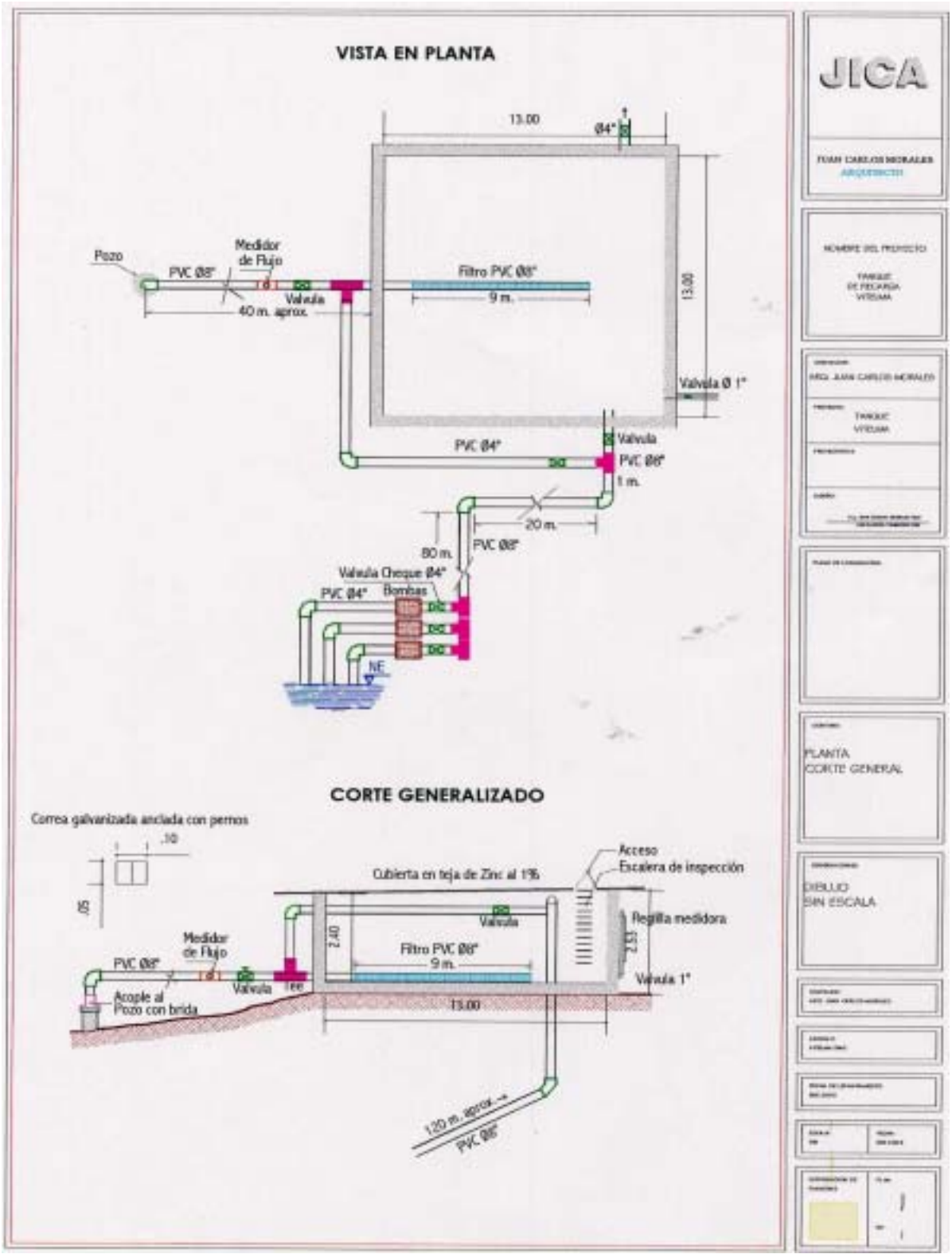

Figure-3.1 Facilities for Pilot Study

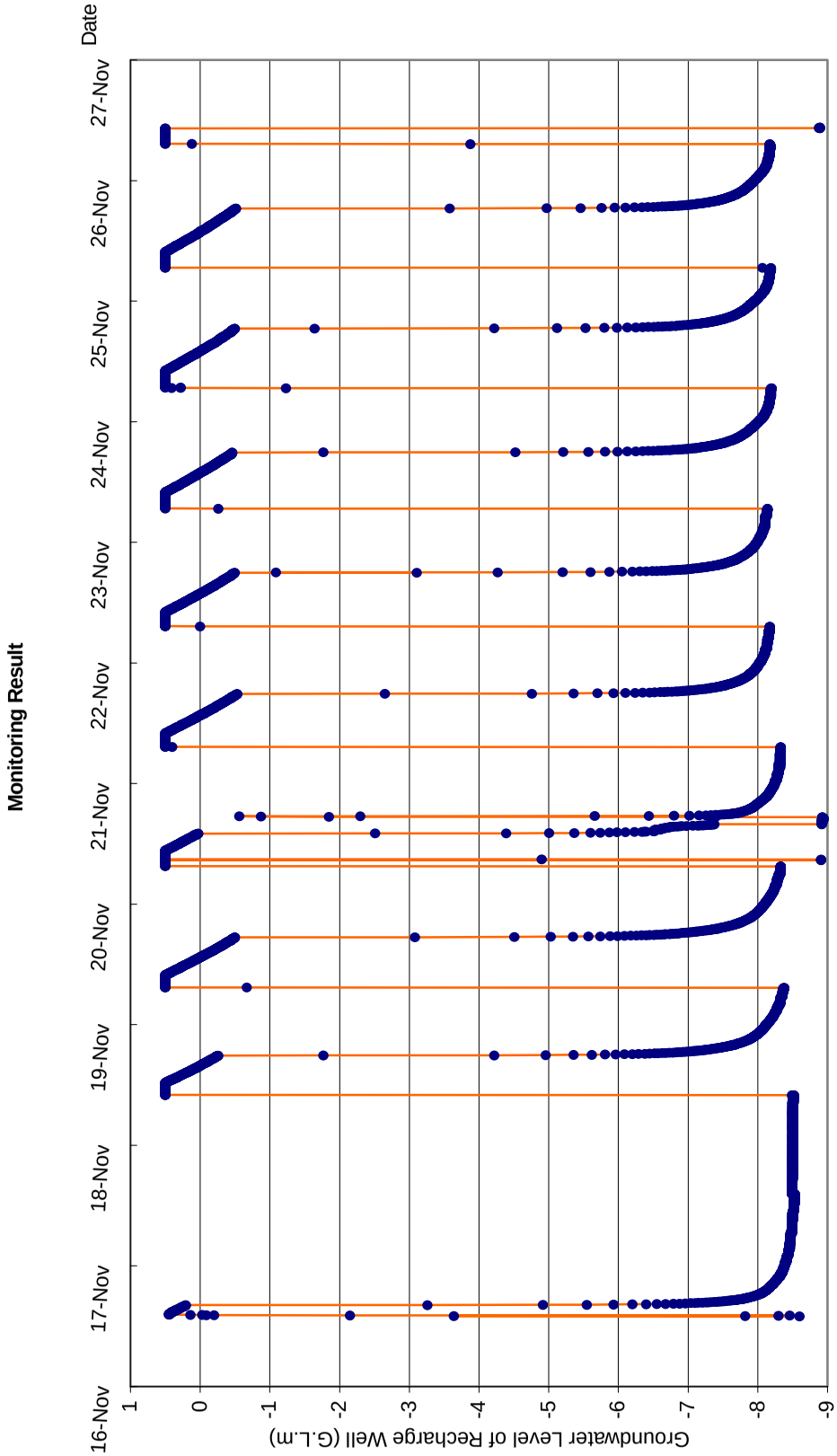

Figure-3.2 Result of Pilot Study