CHAPTER 7 GROUNDWATER MANAGEMENT PLAN

Groundwater development, by deep tube wells, in the Study Area was practically started in the 1970s and has been increased rapidly from the middle of the 1980s. The pumped water is used mostly for drinking, and partially for irrigation and industry. However, the water right on the groundwater is not clearly established in Nicaragua. This implies lack of enactment or enforcement of a general legislation on water resources, or a specific law on groundwater. In other words, groundwater development has proceeded without giving due considerations to the fundamentals of groundwater management.

Groundwater has been the only usable water resource in the Study Area. As such, haphazard and excessive drillings were conducted in the 1980s due to the rapid expansion of the Managua City. Consequently, over-pumping is presumed to exist in some of the city areas, and the problem of decreased productivity of wells is evident in some areas.

Therefore, the rational management of groundwater resources based on the scientific approach, and groundwater development under the concept of "permissive yield" is perhaps the most significant action that can be taken until alternative water sources are developed.

The groundwater management plan must be established in order to protect and utilize effectively this vital resource, seeking to satisfy the rapidly expanding demand forecasted in Managua City until the year 2000.

7.1 Basic Policy

7.1.1 Relevant Concepts

As discussed in Section 5.1, available pumping discharge is termed as "permissive yield", which is the amount determined by the following factors.

(a) Economic factor

This factor reflects the adverse effects from pumping, like dry well, increasing pumping cost, land subsidence, groundwater contamination and groundwater salinization by the declining groundwater level.

(b) Natural water balance factor

This factor refers to the possibility of continuous pumping without causing special adverse drawdown, as determined by the natural recharge capacity of the area.

In the case of the Study Area, the following measures are recommended from the viewpoint of effective utilization of limited resources.

(a) The pumping yield should be restricted by the natural recharge value, which can be scientifically estimated.

(b) Even in the secondary balance condition under extraction, the groundwater level should not be lower than the water level of Lake Managua, in order to protect the groundwater from intrusion of contaminated lake water.

(c) The adverse effects on existing tube well should be minimized.

(d) The range of the dynamic water level of the wells located within 2 km from Lake Managua should be specially controlled.

7.1.2 Priority in Groundwater Use

According to the roughly calculated water balance, the central hydrogeological sub-basin faces the over-pumping problem, and the eastern hydrogeological sub-basin can be developed but without the potential to fully satisfy the demand in the year 2000. This evaluation is still tentative because many assumptions used in the simulation model were rough estimations. This implies the need to review the results of the water balance analysis with the input of more precise and newly collected data from additional monitoring, which is to be conducted under the groundwater management plan.

In order to set priorities in the utilization of water resources, the water right concept is most important. For example, in the case of the USA, the National Conference of Commissioners on Uniform State Laws prepared the Model Water Use Act of 1958 through the Special Committee for Model Conservation and Water Resources Act. This model act states that all the water resources are for public use, and the Water Resources Commission is the authority in charge of all the management and regulation of water resources.

From the viewpoint of utilization of water resources, drinking water is given the highest priority. In this regard, the organization undertaking public supply of drinking water is authorized to take the necessary amount of water from all the water sources.

In the case of Nicaragua, preparation and enactment of a Water Resources Law, including groundwater, is urgently needed because of the expected rapid population growth around Managua City, while groundwater resources are increasingly scarce.

In the absence of a water legislation, the following recommendations are valid for the present and the near future in the Study Area.

(1) The groundwater use for irrigation and industry should not be increased more than the existing level in the central and eastern Managua hydrogeological sub-basins. In the case of exceptional installation of new industrial plants in the said sub-basins, water for the industry is recommended to be purchased from INAA, rather than allowing the drilling of own wells.

(2) The groundwater level in the spring zone around the lowland in Sabana Grande will be affected by the development of new wells in the upper area. However, water utilization in the area is almost exclusively for recreation and irrigation, thereby justifying some decrease in the spring flow.

7.1.3 Water Saving

It is extremely important to undertake practical actions on water saving in the Study Area. Water saving actions should concentrate on two aspects, one of which is to decrease water conveyance loss ("physical loss"), and the other is to prevent wasteful water use in the household ("non-physical loss").

(1) "Physical" loss or leakage is reflected in increased unit cost of production. This type of loss is to be countered with the rehabilitation program of the pipeline and storage tanks, in addition to the installation and repair of meters to accurately measure water production.

(2) "Non-physical" loss refers to water consumed but not paid for, and is reflected in lost revenues. This type of loss is to be countered with the following three actions.

1. Installation or repair of water meters appropriate to each consumer category.

2. Consumer education to encourage good quality plumbing works, and to prevent misuse of water. This campaign should involve not only INAA but also the Ministry of Education and the Ministry of Health.

3. Progressive water tariff, that is, water charges that rise with increasing consumption blocks. This is the tariff structure prevailing at INAA.

7.1.4 Groundwater Pollution and Future Water Source

Once the groundwater is contaminated, water use has to be completely stopped. Because of the strict quality requirement of drinking water, it is important that the aquifer be protected from any kind of contamination.

From the above viewpoint, close attention should be paid to the following areas.

(1) Sabana Grande - Veracruz area is presently used as agricultural land. Then, groundwater contamination by agricultural chemicals is a distinct possibility. Therefore, periodic water quality analysis is recommended to continue into the future.

(2) Lake Masaya is considered as a very important water

source for all the potential areas in the eastern hydrogeological sub-basin. Therefore, the waste water should be treated before being discharged into the lake.

(3) Lake Nicaragua is expected to become the dominant water source in the future. It is therefore strongly recommended to regulate the waste water presently drained into the lake, and to undertake the water quality monitoring.

(4) Lake Nejapa and Tiscapa were already drained waste water around lakes. In case of Lake Nejapa, it is necessary to consider this condition because of the possibility the contaminated water will connect to lake Asososca.

7.2 Groundwater Management

7.2.1 Groundwater Management Target Area

The management target area is the Study Area, including the Managua central and eastern hydrogeological sub-basins, and parts of the western sub-basin. The western hydrogeological sub-basin has to be hydrogeologically investigated in the Los Brasiles area, and the formulation of a separate groundwater flow model is recommended. Each basin has to be treated as an integrated hydrogeological basin because all the human activities influence the aquifer.

(a) Central hydrogeological sub-basin

This sub-basin is the area where groundwater use is to be regulated because of the presumed overpumping.

(b) Eastern hydrogeological sub-basin

This sub-basin is the area to be developed as the new water source for drinking water. The recharge zone for this sub-basin is important and should be protected from any harmful activities.

7.2.2 Tentative Pumping Restriction

The basic ideas on the pumping reduction plan were simulated and discussed in Chapter 5. Hence, only tentative regulation is discussed here.

The most important target of reduction is the pumping at Lake Asososca, because once waste water intrudes into the lake water and makes it unsuitable for drinking, one-third (in 1991) of water supply source for Managua City has to be stopped. Pumping discharge from the Lake was reduced from 67,000 m3/day (average in 1991) to 55,000 m3/day (average in April 1992). It is difficult to clearly ascertain the effects of this pumping reduction on the recovery of the lake water level, because of the continuous drought in recent years and the shortage of new data. Future monitoring results and rainfall data should be considered in evaluating the recovery of the lake water level.

The groundwater level in the central area of Managua City is also predicted to decrease, if the present pumping rate continues and rainfall is normal. However, the detailed behavior in this area has not yet been clarified. Therefore, pumping control in this area should be considered in conjunction with monitoring results, which will be discussed later.

7.2.3 Monitoring Program

Monitoring is a very important factor for the groundwater management, because all the countermeasures can be devised according to the newest condition as revealed by monitoring results.

Basically, all the meteorological records shown in Section 4.3, were collected from INETER. During the course of the Study, five automatic water level recorders and a rainfall gage were installed. Monitoring by using these equipments has been conducted by INAA counterpart team, who periodically has collected and interpreted data from analog to real records. Additionally, water levels of more than 40 wells were measured during the dry and the rainy seasons, as simultaneous survey.

All the pumping discharge records maintained by INAA were collected from the Maintenance Section. The pumping discharge of private wells was estimated based on the interview survey.

Reviewing the approach used for data collection in the Study Area, the following monitoring program will be required.

(1) Rainfall

Daily rainfall data should be collected around La Concepcion and Sabana Grande-Veracruz in order to obtain a more accurate estimation of areal rainfall.

(2) Water Level

Continued monitoring of groundwater level is most significant for groundwater management, because existing data was not enough to fully understand the real groundwater movement. Consequently, results from groundwater level monitoring will permit the review and modification of the assumptions in the simulation model. And, the groundwater management plan should be modified according to simulation results obtained from revised assumptions.

The following additional sites for the monitoring of the groundwater level are suggested.

(a) Near Lake Managua
(b) Between lake Asososca and the industrial zone
(c) Areas where no monitoring equipment exists, but where data are required from the hydrogeological viewpoint

Fig. 7.2.1 shows the location of the existing monitoring system, and the recommended points for monitoring rainfall and groundwater level.

(3) Water quality

Water quality monitoring of the lakes, pumping stations and selected points of the distribution system has been periodically conducted since 1990 by the INAA O/M Department.

Water quality monitoring acquires special importance in reference to the possible intrusion of waste water into the groundwater aquifer of Lake Asososca. Periodic observation, and a weekly or monthly water quality analyses, will be required for lake Asososca and some wells between the industrial area and the Lake. Water samples from some monitoring points used during the Study are also recommended to be analyzed annually.

(4) Groundwater use survey

The lack of discharge meters in INAA's production wells makes uncertain the basic factor in hydrogeological investigation, that is, water extraction data, thereby making tentative even the results from simulation analysis. Therefore, accumulative discharge and pressure meters should be installed in all the wells and other necessary points of the distribution line, in order to grasp the pumped production.

Additionally, the pumping discharge data of private or public wells for industry, agriculture and domestic use are also to be collected. The periodic reporting on water consumption will be required under legal provision, in the case of consumers pumping more than a specified amount.

7.2.4 Sub-studies (Sub-projects)

The following sub-studies are considered to be tentatively necessary, on the basis of the above mentioned monitoring data.

(1) Groundwater Contamination Survey

Groundwater contamination survey should be started as soon as possible in the areas around lake Asososca and the southern side of Lake Managua. This study is to be composed of the water quality analysis and the groundwater flow analysis.

(2) Review of the simulation analysis

As described in Chapter 5, the simulation analysis was conducted based on many roughly estimated assumptions. It is strongly recommended to review all the parameters employed in this simulation analysis after 2-3 years, with the addition of the above mentioned monitoring data.

(3) Establishment of New Models

In this Study, the whole Study Area was modeled as one simulation area. When detailed groundwater level records and other field data become available from the above suggested monitoring program, it is recommended to establish sub-models representing smaller areas, such as Lake Asososca and Sabana Grande sub-models.

(4) Recharge Analysis

Recharge analysis should be conducted by using the data from daily rainfall and daily groundwater level in the Central and Eastern hydrogeological sub-areas, after collecting monitoring data for 2-3 years. The tank model or some other method, which can consider the water balance in the soil condition, is recommended for the analysis.

7.2.5 Time Schedule

The groundwater management is to be implemented in the following phases.

(a) Phase I

All wells, except for small shallow wells for personal use, are to be registered in the well inventory, along with the corresponding data on water level, water quality and quantity. These data serve as bases for hydrological studies, which will yield an evaluation on present problems.

The evaluation results from hydrological studies will be used to classify the groundwater management area into sub-areas, for each of which tentative targets will be set concerning the permissible yield and the quality of water.

(b) Phase II

Groundwater use under the tentative target is to be reduced through rationalization of existing operations. The monitoring system is to be improved, and all the results are to be integrally evaluated. The targets of permissible yield and water quality are to be clearly defined.

(c) Phase III

Monitoring and regulation are to proceed continuously. In this phase, the original problems will have almost ceased to exist. Otherwise, new and more stringent targets will have to be set.

Based on the above considerations, the tentative management schedule will be as follows, with appropriate adjustments according to monitoring results.

1993-1994 Establishment of the monitoring system Establishment of the water resource (groundwater) management committee Rehabilitation project Extraction from Lake Asososca at present level Establishment of a tentative regulation plan according to monitoring results

1995-1999 Development project in Ticuantepe & Sabana Grande Evaluation of the final development scale in the Study Area Review of the tentative regulation plan Establishment of the final regulation plan Regulation in some parts of the area

2000- Development of the full groundwater potential Establishment of the full scale control under the Groundwater Management Plan (Regulation of Groundwater Management)

7.2.6 Organization

Groundwater management in the Area is recommended to be unified under one committee, with members representing concerned organizations. This is because groundwater resources are utilized not only as drinking water but also for industry and agriculture, in Managua City and other surrounding municipalities. INAA should have the leading role in this committee for the investigation, observation, analysis and evaluation of groundwater.

INAA, INETER and IRENA are the main government institutions with responsibilities for natural resources in Nicaragua. INAA is in charge of the particularly difficult responsibility to develop water sources and supply drinking water to the Nicaraguan people, through the rational utilization of scarce water resources. From this viewpoint, INAA is recommended to head the Executive Management Committee, which is to be composed of representatives from INAA, INETER and IRENA.

Legal basis

Groundwater management regulation	Nicaragua Managua

Executive Management Committee

Groundwater Management Committee	INAA INETER IRENA

Management Office

Management Office Executive Staff	INAA

Main Jobs

Groundwater Development Research Permit and Registration of New Well Drilling Management of the Monitoring System Control of the Pumping Discharge Reservation of the Groundwater Recharge Area Water Quality Control

7.3 Alternative Water Sources

According to the results of rough water balance analysis and demand estimation, it is strongly recommended to develop alternative water sources as early as possible. Two possible alternative water sources for Managua City are as follows.

(1) Groundwater development in Tisma-Granada Area

(2) Water conveyance project from Lake Nicaragua

Detailed contents of these projects are mentioned in Chapter 8. Early monitoring of groundwater level, river discharge and rainfall is recommended before start of detailed investigations as specific projects.

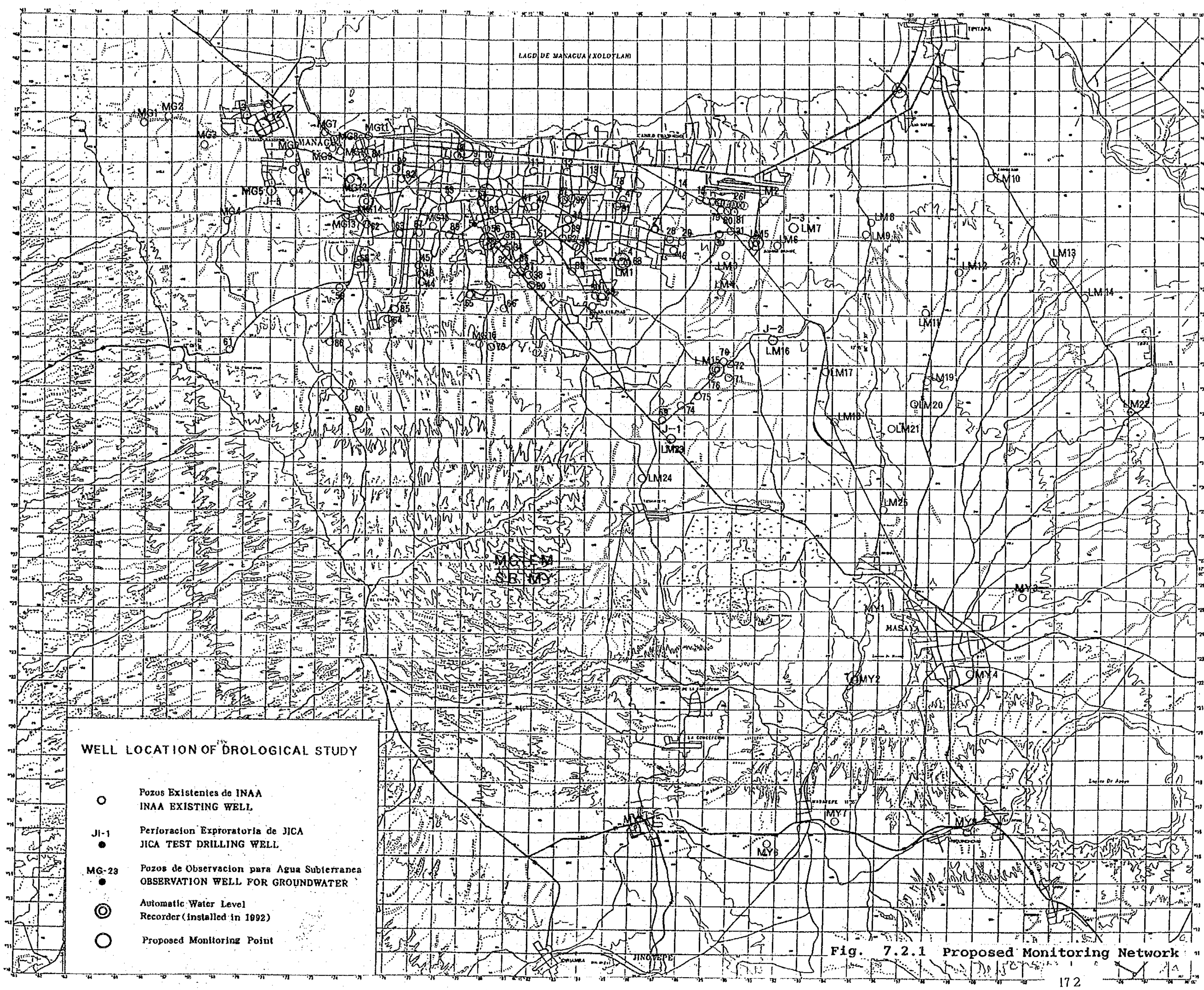

Fig. 7.2.1 Proposed Monitoring Network

CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

8.1.1 Hydrogeological Condition of the Study Area

The Study Area covers the catchment area of the "South of Managua Lake" and has a total area of 880 km^2. It is divided into three hydrogeological basins, namely the western sub-area (65 km^2 and more to the north), the central sub-area (245 km^2) and the eastern sub-area (570 km^2). The hydrogeology of this area, being situated in the southwestern margin of the Nicaraguan Depression and covered by thick sediments of various volcanic materials, is generally good in view of topography, geology and recharge condition, especially the eastern sub-area which is considered particularly good for groundwater development.

8.1.2 Groundwater Development Potential

The groundwater development potential of the Study Area is estimated approximately at 158.5 million m^3/year (114.72 MGD), and the distribution of this potential in the three sub-areas is as follows:

Sub-area	Potential of groundwater development/ Permissible amount of groundwater development
Western Sub-area	8.9 million m^3/year (6.44 MGD)
Central Sub-area	41.6 million m^3/year (30.11 MGD)
Eastern Sub-area	108.0 million m^3/year (78.17 MGD)

8.1.3 Pumpage from the Study Area and Groundwater Balance

The total pumping discharge of groundwater from the Study Area as of 1991, including pumpage from Asososca Lake, amounts to 111.78 million m^3/year (80.91 MGD). The remained development potential in the entire Study Area, therefore, is 46.72 million m^3/year (33.81 MGD). However, the figures depicting "balance" differ in the three sub-areas, as shown below:

Sub-area	Discharge (pumpage) as of 1991	Remaining groundwater development potential (Balance)
Western Sub-area	3.11 million m^3/year (2.25 MGD)	4.19 MGD
Central Sub-area	69.45 million m^3/year (50.27 MGD)	-20.16 MGD
Eastern Sub-area	39.22 million m^3/year (28.39 MGD)	49.78 MGD

The negative potential of the central sub-area indicates over-pumpage which has caused the drawdown of the groundwater level around the area as well as that of Asososca Lake, resulting in fear of water quality deterioration due to the intrusion of the contaminated water of Lake Managua.

8.1.4 Water Production by Water Use Category as of 1991 and Water Demand in 2000

As of 1991, developed groundwater has been used for various purposes and is expected to be of further use in the future also. The total amount of water produced in the Study Area as of 1991 is 80.91 MGD and the estimated total demand in 2000 is 150.05 MGD. These figures indicate that the amount of groundwater to be further developed in the area (a maximum of 114.72 MGD) will not be able to cover the total demand in 2000, even if it is only limited to supply for the demand in the present Managua water supply system.

The breakdown of production as of 1991 and demand in 2000 by category of water use is as follows:

Water Use Category	Production as of 1991	Estimated Demand in 2000
Managua Water Supply	70.94 MGD	138.88 MGD
Municipal/Rural Water Supply	4.81 MGD	6.01 MGD
Industrial Use	4.26 MGD	4.26 MGD
Agricultural Use	0.90 MGD	0.90 MGD

8.1.5 Balance between Development Potential and Demand in 2000 in the Managua Water Supply Scheme

If the demands of other water use categories were previously subtracted from the total groundwater development potential, the remaining potential will be only allocated for Managua Water Supply to clearly determine the balance between the demand in 2000 and the groundwater potential as shown below:

Sub-area		Potential allocated to Managua Water Supply in 2000	Demand in 2000	Balance
Western S.A. (District 1)		6.44 MGD	9.15 MGD	-2.71 MGD
Central S.A.	District 2-6	25.85 MGD	129.73 MGD	-32.62 MGD
Eastern S.A.		71.26 MGD		

8.1.6 Permissible groundwater to be developed in the Study Area as Managua Water Supply Source

Since some groundwater amount has already been developed in each of the sub-areas by 1991, the estimated remaining potential is as follows:

Sub-area	Development Potential	Amount developed by 1991	Remaining Development Potential after 1991
Western Sub-area	6.44 MGD	2.25 MGD	4.19 MGD
Central Sub-area	25.85 MGD	46.01 MGD	-20.16 MGD
Eastern Sub-area	71.26 MGD	22.68 MGD	48.58 MGD

8.1.7 Formulation of the Groundwater Development Project for the Water Supply for District 2 to 6

Based on the results of both groundwater and supply system related studies, the groundwater development project intended to meet the demand in 2000 was formulated as a part of this Study.

Since the remaining groundwater development potential of the Study Area is not enough to cover the demand of the target year 2000, the objectives are expected to be achievable through the development of groundwater outside of the Study Area.

The project is to be implemented in three phases, and the following outputs are expected from each project phase:

Phase 1: By the development of 18,74 MGD of groundwater from one of the two promising areas (North Ticuantepe) in the eastern sub-area, severe inconveniences such as periodical water suspension and very limited supply to highly elevated areas will be minimized.

Phase 2: By the full development of the remaining potential of 29.84 MGD of groundwater in the other promising area (Sabana Grande) in the eastern sub-area, the average daily supply of water per head for domestic use will be increased from 170 l/c/d to 208 l/c/d leading to the attainment of more than 90% of the project objectives.

Phase 3: The development potential in the eastern side of the Study Area is unknown. Therefore, this study is necessary in order to formulate a detailed plan. The required amount of water to be produced by the supplementary sources to meet the demand in 2000 is 12.46 MGD, but to replace the amount excessively pumped up at the central sub-area, 12.46 to 32.62 MGD of groundwater is to be developed in this phase.

8.1.8 Project Cost Estimate

The total cost for the implementation of the Project is estimated to range from C$ 748 million to C$ 1,053 million.

The cost for each project phase is estimated as follows:

Phase 1: C$ 210 million for the construction of 14 wells at North Ticuantepe and a conveyance system connected to the Las Americas No.4 reservoir, including the installation of 2 sets of 11,000 m^3 reservoir tanks.

Phase 2: C$ 349 million for the construction of 19 wells at Sabana Grande and a conveyance system connected to the Las Americas No. 4 reservoir, including the installation of 2 sets of 15,000 m^3 reservoir tanks.

Phase 3: Between C$ 189 million and C$ 494 million for the development of 12.46 to 32.62 MGD of groundwater outside of the Study Area and the construction of a conveyance system and reservoir tank, including expenses for the execution of a development study. The Phase 3 project cost has been roughly estimated assuming a unit development cost 1.4 times higher than that in Phase 2.

8.1.9 Operation and Maintenance Cost for the Facilities Constructed in Phase 1 and Phase 2

The annual operation and maintenance cost for facilities constructed in phase 1 and 2 is estimated at C$14,318,000, referring to a unit production cost of C$0.21 per cubic meter/day.

8.1.10 Project Evaluation

The financial evaluation of Phases 1 and 2 of the Project indicates that the Project is hardly regarded as "feasible", since FIRR is only 4% under assumptions of such conditions as:

(a) Favorable sold water: 75% of production
(b) Water charge collection rate: 85%

However, in consideration of great social benefits and associated favorable effects by the Project, the immediate implementation of the Project is highly recommended, if a sufficiently "soft" financing can be secured.

8.2 Recommendations

8.2.1 General

In order to improve the present water shortage condition in the Managua water supply system, the Project should be urgently implemented. INAA, the executing body of the Managua water supply system, is responsible for upgrading the supply system worthy of that of the capital city of Nicaragua.

Groundwater is a valuable natural resource, especially for the Managua water supply system. Since Managua City nearly covers one third of the total population of the Republic of Nicaragua, the water supply scheme for its capital city should be recognized as a national project. Accordingly, laws and regulations on groundwater development and management should be formulated, mainly to protect the water supply sources in and around Managua.

Previous to or simultaneous with the implementation of the Project, the mitigation of excessive pumpage in the central sub-area should be taken into consideration in order to eliminate the fear of water quality deterioration due to the intrusion of the contaminated waters of Lake Managua. The mitigation of excessive pumpage is to be attained not only by the reduction of pumpage from Asososca Lake, but also by reducing or preventing increase in pumpage from the wells in the central sub-area.

8.2.2 Groundwater Monitoring and related Studies

(1) Groundwater Monitoring

In order to establish the groundwater management system, the groundwater monitoring should be started as soon as possible. Excessive pumpage in the central sub-area will undoubtedly have to be minimized soon. To determine when and how the reduction of excessive pumpage in the central area is achieved, groundwater discharge, groundwater level, water quality and rainfall in the catchment area should be continuously monitored. Flow meters should be attached to all wells to ensure the monitoring of groundwater discharge by well pumps. Additional rainfall gauge should be installed also in Sabana Grande to strengthen the rainfall gauging network.

By use of the data collected from the monitoring work, the review of the groundwater flow simulation should be conducted.

(2) Groundwater Development Study in the east of the Study Area

In order to formulate the groundwater development plan for the Phase 3 of the Project, the Study which cover the area from the east of the Study Area to the Lake Nicaragua should be conducted before the completion of the Project.

The items to be involved in the Study is as follows;

- Hydrological and hydrogeological surveys to confirm the groundwater development potential
- Groundwater use especially on agricultural use, since agricultural production activity is widely developed in this area
- Water quality focusing on chemicals for the agricultural use

(3) Groundwater development study in the north of the western sub-area

The independent supply area, District 1, is obliged to remain as independent supply area in the future due to the presumable non-cost-effectiveness of the water transmission from the east.
Since the shortage of supply source in the near future is forecasted, the Study area should be expanded to the north to cover the entire catchment area of the western sub-area.

(4) Feasibility Study on the water of the Lake Nicaragua as the source of Managua water supply

The feasibility study on the Nicaragua Lake water is recommended to be conducted simultaneously with above Study(1). The supplementary water source to meet the demand of 2000 may be developed from the east of the Study Area, however, it will become insufficient within several years after 2000, even though the demand increase is decelerated.

(5) Staff Training

Groundwater development has its own comprehensive technology and the component technology are far-reaching thus vast knowledge and experience are essential. Consequently, a necessary condition for the groundwater engineer is that he/she possesses as the technology which corresponds to the specialized fields of groundwater exploration, well drilling, pumping test, quantitative analysis, development and monitoring. In the future, it is expected that the concerned agencies choose the proper personnel for the detailed design stage and the construction stage of the project in order to improve the level of the engineering staff through on-the-job training.

8.2.3 Water supply facility related

(1) Release of the well pumps from overload

In order to make higher of the well pump efficiency, the pumped water should once be stored in the storage tank beside the well group, without being connected directly with the transmission or distribution pipes of the Managua water supply system.

(2) Increase of the capacity of the reservoir tank

Since the total capacity of 7.5 hours retention time is too small in the existing system, the increase of the capacity by construction of new reservoir should be involved in the rehabilitation or improvement program on the supply system.

(3) System improvement on Rafaela Herrera pump station

The pump station of Rafaela Herrera seems to be particularly overloaded. The system of the water transmission system, therefore, is an urgent necessity. The installation of the reservoir tank is suggested to be one of the solution of the overloaded problem.

(4) Reduction of leakage

The effort to mitigate the water leakage should be continued in order to effectively use the limited source.

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