3RD ASIA PACIFIC REGIONAL WATER SUPPLY CONFERENCE AND EXHIBITION

NOV. 15 - 19, 1981
PICC, MANILA PHILIPPINES

INTERNATIONAL WATER SUPPLY ASSOCIATION · ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

PROCEEDINGS

PHILIPPINE WATER WORKS ASSOCIATION

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Conference Objectives

All international conference generally share a common goal of bringing about a meeting of minds among representatives regarding major topics of concern, or at a minimum to create an open dialogue and sharing of experience and problems common to all. The 3rd Asia Pacific Regional Water Supply Conference and Exhibition is no exception. It aims to create awareness of new potential technologies which may be adapted for local applications. Since it concentrates on water supply technology, the conference has the aim of firming the commitment to pursue the objectives of the International Drinking Water and Sanitation Decade.

Date and Venue

The conference was held from November 15, 1981 to November 19, 1981 at the Philippine International Convention Center, Roxas Boulevard, Metro Manila, Philippines.

Attendance

Delegates from twenty six (26) countries all over the world attended the conference. Two hundred sixty three (263) foreign delegates and over four hundred fifty (450) Philippine delegates have participated on this occasion. Member countries include the following list: Australia, Belgium, Canada, Republic of China, Denmark, England, France, Germany, Hongkong, India, Indonesia, Italy, Japan, Korea, Malaysia, Netherlands, New Zealand, Norway, Philippines, Saudi Arabia, Singapore, Sweden, Switzerland, Thailand, Kingdom of Tonga, and the United States of America.

Host Organizations

The Philippine Water Works Association hosted the event in collaboration with the International Water Supply Association.

OFFICE OF THE PRESIDENT

Malacañang Palace

Manila

MESSAGE

It is with distinct pride and honor that I welcome to Manila the delegates to the Third Asia-Pacific Regional Water Supply Conference and Exhibition.

This gathering of acknowledged experts in the field of water supply from various countries in Asia, Europe, America and Oceania is indeed very significant as this decade has been declared by the United Nations for the concentrated pursuit of water supply development. It also comes at a time when the country is at the midst of implementing a comprehensive program towards the attainment of full water supply coverage by the year 2000.

I hope that this conference and exhibition will result into accelerating our effort as well as that of other developed and developing countries in the region in this vital field through the introduction and assimilation of modern and more applicable, not to say practical, technologies and concepts, and in the process contribute to the betterment of quality of life in this part of the globe.

I would like to affirm my appreciation to the organizers and sponsors of this international meeting, specifically the Philippine Water Works Association (PWWA) and the East Asia Regional Committee of the International Water Supply Association (IWSA).

Again, welcome to Manila and I wish you all success.

FERDINAND E. MARCOS
President of the Philippines

Republic of the Philippines
MINISTRY OF HUMAN SETTLEMENTS

MESSAGE

I congratulate the Philippine Water Works Association (PWWA) organizers of the Third Asia-Pacific Regional Water Supply Conference and Exhibition and warmly welcome to Manila the foreign delegations to the conference.

The Philippines, indeed, takes great pride in being chosen as the venue of this historic gathering of the world's renowned technocrats and experts in water supply. The country had seen bleak period in the past in this respect. With the advent of the Society of Man, however, we have been working — and with some success — in ensuring the provision of safe, adequate, water for all Filipino homes as part of our overall program for the betterment of the quality of our life.

It is my fervent hope that this international meeting will open new vistas and give more emphatic directions to our efforts and the efforts of other Third World countries in the provision of this basic need which is vital not only to our survival but to our socio-economic progress as well.

IMELDA ROMUALDEZ MARCOS
First Lady, Metro Manila Governor,
Minister of Human Settlements

PHILIPPINE WATER WORKS ASSOCIATION

MESSAGE

This is the first time that the Philippines hosts an international water supply meeting of this magnitude and importance with the holding here of the 3rd Asia-Pacific Regional Water Supply Conference and Exhibition.

I surely am happy and honored that the Philippine Water Works Association (PWWA) is playing significant role in bringing over the conference here at a time when most countries in the region are deeply negated in water supply development. This is quite an achievement for an association barely three years old.

I hope that the conference will succeed in attaining its objectives of demonstrating awareness in new potential technologies in water supply and of pursuing the aims of the United Nation's declared International Water Decade.

I wish to thank the East Asia Regional committee of the International Water Supply Association (IWSA) for its help in organizing this conference here.

OSCAR I. ILUSTRE
President, PWWA
General Manager, MWSS

PROGRAM

THIRD ASIA-PACIFIC REGIONAL
WATER SUPPLY CONFERENCE AND EXHIBITION
November 15-19, 1981

OPENING PROGRAM

MONDAY, NOVEMBER 16

Plenary Hall, Philippine International Convention Center

9:00 A.M. – ASSEMBLY OF DELEGATES

9:30 A.M. – NATIONAL ANTHEM . . . . . . AWENG PHILIPPINES MALE CHORALE

OPENING REMARKS . . . . Mr. OSCAR I. ILUSTRE
President, Phil. Water Works Association

MUSICAL INTERLUDE . . . . AWENG PHILS. MALE CHORALE

INTRODUCTION OF THE GUEST OF HONOR . . . . Hon. JESUS HIPOLITO
Minister of Public Works and Highways

ADDRESS . . . . Madame IMELDA ROMUALDEZ-MARCOS
Minister of Human Settlements &
Governor of Metro Manila

Presentation of the Resolution & Pledge of Commitment to the Guest of Honor . . . . Mr. OSCAR I. ILUSTRE

RECESSIONAL

EXHIBITS OPENING . . . . Executive Lounge of the P.I.C.C.

MASTER OF CEREMONIES . . . . . Mr. CARLOS C. LEAÑO, JR.
Vice-President for National Affairs
Phil. Water Works Association

MR. CARLOS LEAÑO:

Our beloved First Lady of the Philippines, Minister of Human Settlements and Governor of Metro Manila, Madame Imelda R. Marcos; Prime Minister Cesar Virata; Minister of Public Works and Highways, Jesus Hipolito; Mr. Maarten Schalekamp, now Vice-President and incoming President of the International Water Supply Association; Vice-Governor of Manila, Ismael Mathay, Jr.; President of the Philippine Water Works Association, Oscar Ilustre; Vice-President for International Affairs of the Philippine Water Works Association, Lamberto Ocampo; distinguished guests, delegates to the 3rd Asia-Pacific Regional Water Supply Conference and Exhibition, Ladies and Gentlemen: A pleasant good morning to all of you. To start our program, AWENG Philippine Male Chorale will sing our National Anthem.

(NATIONAL ANTHEM)

MR. CARLOS LEANO:

Thank you. The President of the Philippine Water Works Association, Mr. Oscar Ilustre will now deliver the welcome remarks.

MR. OSCAR ILUSTRE:

Madame Imelda R. Marcos, Minister of Human Settlements and Governor of Metro Manila; Prime Minister Cesar Virata; Minister of Public Works and Highways, Jesus Hipolito; Mr. Schalekamp, fellow delegates, distingiushed guests, ladies and gentlemen.

The selection of Metro Manila as the venue for the 3rd Asia-Pacific Regional Water Supply Conference is a signal honor for the Philippines. It is also a tribute to the officers and many members of the Philippine Water Works Association for having succeeded in bringing together under the roof of these magnificent structures the international figures and experts in various disciplines in the water supply sector in their respective countries. So that gathered here today are some 700 delegates, 300 of whom have come from 21 countries around the globe. We do have also 400 delegates of the engineering and allied professions from all parts of our country, both from the public and private sectors.

Our having gathered in Manila is very suspicious and timely in the sense that we are just entering the second year of the U.N. Water and Sanitation Decade of the 80's. With this agrupation of the 80's. With this agrupation of international talents and leaders, we hope to achieve a commonality of interest by learning from one another. Thru this conference, there will be exchanges of views and knowledges and discussions of development of strategies and thrust. Our objective is to help achieve the desires of the peoples in this part of the world to help bring about in the fastest time possible and at the least cost, to the remotest corners of our country and to all our peoples the benefits of a very basic human need, water, which for centuries has been denied to billions of them. For we in the Third World are faced with a very basic and common problem – the meagerness of our resources, as opposed to the many competing claims, all of which appear of high priority. Barely some of our strategies in the development of our water supply have heretofore leaned towards goals and scales which we in the Third World can ill afford. The time has come when with very limited resources, the countries of this region have to opt for strategies and systems that are both appropriate to our needs and very well within our means. And so here in the Philippines, while it is true that all our major urban metropolis plans for development approximate those obtaining in the western world and we also have parallel and corrolary plans for our rural areas and the so-called urban poors, these are oriented more towards lower standards or levels of service than that required for highly urbanized communities. This is a thrust which our government is for practical purposes, presently adopting in order that we may be able to spread the benefits to many more with whatever resources we have. It is in the improvement of this thrust and strategies that we invite the delegates to this conference to discuss with us and, if we may humbly say so, to be able also to learn from our experiences and even from our mistakes.

Those from the industrialized countries offering the goods and services of their industrialized environments have no cause to worry on this score because, as the poorer nations of this part of the world are able to stretch their resources and thereby as their people improve economically, they create a larger and larger potential market base for many of the goods of others. What we in the Philippines, therefore, are doing is to adopt appropriate technology to achieve economies and thus spread benefits. What we are asking the delegates of this convention is, therefore, to ponder, if not so much to advise us, as to what the most appropriate technology is for any particular country. There is always a danger here, but we are merely to open up the field for discussion of what alternative options exist in the world over, what the potentials are so that each of us in this part of the world may choose to adopt in so far as they are relevant to our social, political, economical and ecological environments. It is therefore, in this spirit, that in behalf of and as President of Philippine Water Works Association, it gives me great pleasure in joining the others in welcoming you to our country to extend to each and everyone of you the greetings of the Philippine delegations and to open our doors to you and let you savour the traditional oriental hospitality of our people. It is fervently hoped that your participation in this conference will be productive and that you will have a pleasant stay during the 5 days that you will be with us. In my other capacity as Chairman of this Conference, I now declare the 3rd Asia-Pacific Regional Water Supply Conference and Exhibition open. Thank you.

MR. CARLOS LEAÑO:

Now the AWENG Philippines Male Chorale will render a song number.

(SONG NUMBER)

MR. CARLOS LEAÑO:

The Minister of Public Works and Highways, Jesus Hipolito, will now introduce our Guest of Honor.

INTRODUCTION OF THE GUEST OF HONOR

Hon. JESUS HIPOLITO:

Prime Minister Cesar Virata; Mr. Maarten Schalekamp, the incumbent Vice-President and President-Elect of the International Water Supply Association; Vice-Governor Ismael Mathay, Jr., of Metro Manila; Engineer Oscar Ilustre, President of the Philippine Water Works Association; Engineer Lamberto Ocampo, Vice-President of the Philippine Water Works Association, distinguished delegates to the 3rd Asia-Pacific Regional Water Supply Conference, our Honored Guest, friends. It is my distinct pleasure and privilege to present to you the First Lady of the Republic of the Philippines, the Honorable Minister of Human Settlements and Governor of Metro Manila, Madame Imelda R. Marcos.

SPEECH OF MADAME IMELDA R. MARCOS MINISTER OF HUMAN SETTLEMENTS AND GOVERNOR OF METROPOLITAN MANILA

MADAME IMELDA R. MARCOS:

Minister of Public Works and Highways, Jesus Hipolito, Prime Minister Cesar Virata; President of International Water Supply Association, Mr. Maarten Schalekamp; Chairman Ilustre, delegates, distinguished guests, my friends.

Allow me, as Governor of Metropolitan Manila to extend a most cordial welcome to all of you, particularly the foreign delegates participating in this 3rd Asia Pacific Regional Water Supply Conference and Exhibition, to this City of affection, Metropolitan Manila.

I am sure that the organizing committee of this workshop conference, headed by Chairman Oscar Ilustre, spared no efforts to make your stay and participation in this conference as comfortable and enjoyable as possible. And in that endeavor, I assure you that the government of Metropolitan Manila will assist in every way possible, for we want this conference to achieve something truly historic and fruitful in the search for solution to the problem of water supply for the populations of the world, whether by the developing or the developed countries. For if this conference succeeds, the beneficiaries will be us and all of humankind. A person they say can live without food for two weeks, but without water, he will perish in five days. Everything that man needs is nurtured by water. In fact, scientists and ecologists tell us that life evolved from water, since life first reared from the waters that attended the birth of our planets millions of years ago. Water has been the medium that nurtures our lives. We can only grow plants or produce foods if there is water. The animals that we grow for meat and for muscle to help us do our work will, like us, perish without water. Even our industries depend on water. Every industrial process in the world today uses and cannot proceed without using water. But because water appeal recently has been relatively plentiful with seemingly inexhaustible capacity for being recycled by natural as well as man-made processes, we have taken the matter of water for granted. But now, it is no longer possible to do so and because we are no longer afforded the luxury of taking water for granted, it is now possible for us to really start to come to grips with the problem and propose and implement solutions both to the problem of water as an ecological and environmental resources and as a human need that must be made available to human beings and human communities at the desired quantities and purity for all human uses from agricultural to industrial, to direct human consumption for drinking, cooking and washing.

To be sure, the dimensions of the problem are impressive and even awesome. According to the U.N., half of the world population is without reasonable access to a safe and adequate water supply.

To achieve the aim of the U.N. Decade on International Drinking Water Supply and Sanitation in 1990, it is estimated that the world will have to spend 80 million dollars every day. But that is not as formidable as it sounds; for strangely enough, while people are awed by the fact that we will need 80 million dollars from day to day to fund a global program on water supply, very few are appalled or even aware that the world is in fact spending 1,400 million dollars everyday or 15 times the amount needed for water, preparing to kill one another with weapons and armaments.

Let me tell you briefly about our own experience in the Philippines. Let me begin by admitting that our problems exist, and it is a serious one. As of 1979, only two thirds of the population of our urban areas and one third of our rural areas had adequate and safe water supply. But instead of dwelling on the problem and losing heart because of its seemingly overwhelming magnitude, we decided to look for and implement solutions. We began with the program to provide all communities, a point source for safe and reasonable water supply. This is level 1 of our water program. Because this is the most basic level that we must do for the entire society, government took it upon itself to provide this service using public funds. In this level, people may have to walk up about 250 meters to a water source point but the water they will get is potable. If they want a more convenient system and they have the means to afford it, we evolved programs for second and third level supply to be financed by loans which will be repaid from collection or payments by users. Level 2 will provide a communial faucet system.

Two key ideas underline these program. The first is that water is one of the eleven basic needs of any human community. We therefore look at the water program not as a sectoral activity, but as part of what we called a human settlements approach to development. Our program, although it employs specialized institutions for the delivery of water as basic community is a wholistic, energestic and mutually supportive and involving all the 11 basic needs so that hand-in-hand with water delivery program, we have simultaneous delivery program for livelihood or economic base, shelter, food, clothing and cottage industries, education and culture, sports and recreation, mobility, ecological balance, medical service and others.

The second key idea underlying our developmental approach in water and all the basic needs of human communities is economic viability. Economic base or livelihood is a key ingredient in our program. Without economic base or livelihood, the community, even assuming for the sake of argument that society can make them available, simply cannot afford the service. Government can provide the initial thrust but the continuance and maintenance of the services depend on the people participating in their upkeep and expansion to other needy communities. This key idea in our human settlements approach to development has now become the main developmental program of our government. This is the KILUSANG KABUHAYAN AT KAUNLARAN or our KKK program meaning livelihood program. We have come to realize that we can have self-reliant, vibrant and achieving citizens and communities only when there is a source of livelihood which will in fact enable them to become self-reliant and independent. Livelihood becomes the self-priming and self-perpetuating engine and instrument for growth and development of our people and our communities. Livelihood is what will make the delivery of the basic needs of people and communities viable and enduring realities. When we begin to contemplate the source and impulse that propel what we are doing not only about water but the basic needs of communities, we will discover that it is not really something superspecial or revolutionary.

In fact, the impulse and basis is so common and revolutionary, we call it "common sense." Of course, people say that common sense is so uncommon because too few have or use it. I do not believe this to be so. Common sense has become uncommon only because we have allowed it to be burried and overwhelmed within our hearts and minds with the full sophistication and falsely seductive dogmas and essence that have separated us from our common humanity.

The English poet, John Donne, tells us and I think we can all agree that "No Man is an Island complete unto himself but a part of a whole." That we are part of mankind and therefore have a stake in the happiness and well-being of the totality of the humankind. What our world needs today is to rekindle in every one this sense of oneness with all of humankind. Perhaps then, we can use water as a starting point for solving our common human problems as we link water to food, ecology, livelihood, energy, mobility and others, as we goal our development programs to man's better quality of life.

To restate the whole thesis of my little speech today, the problem is not so much water supply, as it is the problem of how human beings look up and value the water supply situation. The solution is not providing water as a sectoral or isolated program. It is providing human beings and human communities with the basic services and amenities for human living of which water is one and a beginning, as we concern ourselves for human kind's fullfilment. This is thinking wholistically; this is having a mind that feels and a heart that thinks. God gave man earth and water that it may live and flourish, let us hold water sacred or we all perish. Thank you.

Third Day — November 18, 1981

CLOSING PLENARY SESSION

Presiding Chairman — MR. CARLOS LEAÑO
Vice President for National Affairs
Philippine Water Works Association

MR. LEAÑO:

Ladies and Gentlemen, I am proud to report to you that in this Regional Conference, twenty-six countries participated; the biggest delegation comes from Japan. Official delegates total 682. I think that is almost twice as much as the number that we actually expected. Of this number, 263 came from places outside the Philippines. In addition to this, we have some 82 observers, 21 exhibitors, and some 44 technical papers were read. We are very fortunate that our conference was graced by no less than our First Lady, Madamme Imelda Romualdez Marcos, by the Prime Minister Cesar E. A. Virata, by the President-elect of International Water Supply Association, Mr. Maarten Schalekamp, and by the Secretary General of International Water Supply Association, Mr. Peter Stott. Their presence indicate the importance of this conference, the importance that we attach to water, the major or basic need of mankind.

This conference has convinced us to create awareness of new technologies, potential technologies, as well as actual technologies already in application as suited to our needs, particularly of those developing countries. This conference also was timely because, it provided a stepping stone to the achievement of the goals of the United Nations Water Decade that covers the period of 1980 to 1990. I sincerely hope that this conference was a success insofar as those objectives are concerned. We have said from the start that more than anything else, conferences of this nature not only mean exchange of applicable technologies, but in a larger sense, it means communications — dialogue among countries of the world, particularly, the East Asia Pacific area. With this note, I would like again to thank each and everyone of you, and in behalf of Philippine Water Works Association for your presence, for your having shared with us your ideas, knowledge and your communicating and meeting with each other. We are here together as one people and as one region. Thank you very much.

We will now request each chief delegate from the various countries to give a short remark and response. May I call on the chief delegate from Australia, Mr. John O'Brien.

MR. JOHN O'BRIEN:

The Chairman, Mr. Ilustre, ladies and gentlemen. On my first visit to the Philippines, one of my first visits here, I recall at this moment, the quotation that I read in the office of Mr. Quebral, and it reminds me very possibly, and also tells me that it illustrates some words far better than I could, the need that we should all work together for the common good of mankind. I can't help but find in this conference as to the very sound foundation with its objectives that have already been expressed most eloquently by our beloved First Lady and I'll certainly bring home to my country a very happy memory of your very kind hospitality. And I indeed congratulate you Mr. Chairman for the success of this conference and the organization of it was very largely geared to good organization, and to you, the lot of your officers, I thank you sincerely for the opportunity of my being here.

CHAIRMAN:

We will now award the certificate of .attendance to all the members of delegation from Australia as well as the offering of a momento from the Philippines, the flag of Philippine Water Works Association. May we request Mr. Jean Jacques Bogaerts representing Belgium to give some few remarks. If he is not here, Mr. George Burns from Canada or Mr. Poul Vermehren from Denmark, may we request him if he is around?

MR. VERMEHREN:

Mr. Chairman, ladies and gentlemen, Thank you, first of all, for nominating me as head of the Danish delegation. I was not present the other day, so it was Mr. Plong who stood for me. So I was taken a little surprised but, nevertheless, we have been here in the Danish delegation because, we have worked here for a long time, because we had felt that the friendly relations between the Philippines and Denmark have been so well developed over the last years, and we are most welcome here. We could learn something about water development in the developed countries. The subject we have put in the agenda for this meeting has clearly shown that the Philippines and all other countries in this region has come a long way and can do a lot of this developments themselves today. We have enjoyed it and we have also participated in the exhibition from the Danish site. We have also participated in the lectures of various kinds and I would say like Mr. O'Brien from Australia says we live in the Philippines with the highest regards what has been achieved over the last few years, especially with regard to this conference which built up over the last two years mainly because, of what he said of the Chairman's challenge for organization and his very good colleagues in the PWWA. Thank you very much.

CHAIRMAN:

May we call for Mr. Simon Watt from England. Mr. Simon Watt. . . Mr. Jean Mignot from France, anybody from France who would like to do the honors.

MR. JACQUES CHEVALLET:

Mr. Chairman, ladies and gentlemen, I'm even more caught by surprise than my eminent colleagues from Australia and Denmark before and I simply want to say that although French delegation was small in quantity, I hope it is more in quality. May I just say I don't stand first from the French delegation because, as I said to some of my Filipino friends yesterday and the day before, I really like being in the Philippines (for few years now), and I wish that after this conference, there will be more occasions, more opportunities for that kind of extension of dialogues, and because this has been very fruitful, probably for the Asian representatives; but this is my sincere opinion for the representatives from the other part of Asia Pacific region. Again, thank you very much indeed.

CHAIRMAN:

Delegation from the Federal Republic of Germany, Mr. Gerald Franzmann.

MR. FRANZMANN:

Mr. Chairman, ladies and gentlemen, when I received some months ago the invitation to participate to this conference, I was not in this country, I was at that time in Colombo, but, well it was overseas, because my job came to an end over there. What I wanted to say, is that my first reaction was very spontaneous. And actually, I'm still here and I must say that I enjoyed very much and learned although being professional, and I also learned something new. And I wish to express my thanks for having a chance to join you. Thank you very much.

CHAIRMAN:

The delegation from India, Mr. S. S. Patwardhan.

MR. PATWARDHAN:

Mr. Chairman, ladies and gentlemen, it was really a pleasure for me to come to the Philippines. I have heard a lot about the Philippines in the books and I was very eager to come, and when I came here I was even surprised of the hospitality and excellent arrangement for the convention. Apart from the arrangement, particularly the convention is so important because, of this sanitation decade that what we are going through. It's really a good thing and you know the Indian has to do a lot of work in rural water supply as well as the urban water supply and when I get back home, this conference will be extremely useful. As I shorten my speech, my thanks to all the delegates and also to the administrators of this conference. And one thing I would like to express here, that India could not send more delegates, because this conference is not known to the number of people. I would be happy if more publicity will be given to all countries. Thank you.

CHAIRMAN:

Delegation from Italy – represented by Mr. Francesco Archibugi.

MR. ARCHIBUGI:

Mr. Chairman, ladies and gentlemen, a few more straight words in thanking you for your very kind hospitality and a few words reminding what the First Lady, Mrs. Imelda Marcos said, what was pointed out in this conference, supplying safe water is not only our job, but it is our duty because there are people lacking safe water in the world and it's actually our duty not only our job. So, in the world it was already said, we are spending much more for weapons than for our health, for our own health and everybody else. I think this is something that we should bear in mind and keep it in mind and for our own willingness to behave as a good citizen of the world. Thank you.

CHAIRMAN:

The delegation from Japan represented by Mr. Obarra.

MR. OBARRA:

Mr. Chairman, ladies and gentlemen, this is Mr. Obarra speaking, Director-General of Japan Water Works Association. I want to express my gratitude in behalf of Japanese delegates. This Manila conference gathered the largest number of participants, especially enlightened by the presence of the First Lady of the Philippines in the opening ceremonies which was splendid. All in all, the conference was a big success. This success has been brought about by the remendous preparation of the Philippine Host Committee, especially of the Chairman, Mr. Oscar Ilustre, and other colleagues. We are very pleased for this as one of the proponents to have this kind of regional conference. We are glad to be able to report about this Manila Conference to all the Japanese concerns. Lastly, we want to extend my gratitude again to Philippine Water Works Association and we pray to God to secure our future development. Thank you.

CHAIRMAN:

The delegation from Jordan represented by Mr. Anatole Congorian. . . The delegation from Hongkong represented by Mr. W.D.A. Tucker.

MR. TUCKER:

Mr. Chairman, ladies and gentlemen, first of all I would like to thank you for the invitation to attend this conference. Hongkong is comparatively recent member of the IWSA, and were once represented by one of our members in the conference of this nature previously, that was the one held in Tokyo 1979 which I gathered was successful as this has been. Maybe our participation has been due to our own, to get all our needs to the development of our own country, and we have not been participating mostly to the extent which we should, but this conference has been instructive and it indicated that there can be mutual benefits in the exchange of views and experiences. In the problems, if not identical, I can assure you of our support for the new Asia Pacific Group, and I hope that we will be able to provide some more positive evidence of our participation in the future. Lastly, I like to say thank you, to all of you, and to all the organizers for the excellent way for which you have entertained us and the way you conducted the affairs of this conference. Thank you very much.

CHAIRMAN:

The delegation from the Republic of Korea, represented by Mr. Su Won Kim, – anybody from South Korea please. May we request a delegate of South Korea to do the honors, the delegation from Malaysia represented by Mr. Chan Kok Pew.

MR. CHAN KOK PEW:

Mr. Chairman, ladies and gentlemen, Malaysia as you all know is a young and developing country, and we have come to learn as much as possible from the Philippines. In fact we find that we have a lot in common, especially in the form of extending water supply to the rural area in addition to supplying water to this urban area to cater for the industry's demand. We have also in common the high percentage of water losses which I understand in my country, we have something like in the order of 30% to 40% losses which we can't afford. I would make use of this opportunity to continue to learn and to get the know-how from the Philippines. I'm sure my happy years will come. I like to take this opportunity to thank the Philippine government and in particular the Waterworks authorities for their hospitality and great capability for organizing this conference as a success. Thank you.

CHAIRMAN:

The delegation from Norway represented by Mr. Harald Arvesen. . . Delegation from Saudi Arabia, represented by Mr. Mohamed Al-Othhaim... delegation from Singapore represented by Mr. Koh Boon Aik.

MR. KOH BOON AIK:

Mr. Chairman, ladies and gentlemen, I was the sole delegate sent by the Public Utility Water of Singapore and I automatically became the head of delegation. I am very impressed by the organizers of this conference, and in behalf of the government of Singapore, I take this opportunity to thank the Philippine Water Works Association and the Organizing Committee for making this conference a very memorable one.

CHAIRMAN:

The delegation from Sweden represented by... any volunteers from Sweden. . . The delegation from Switzerland represented by Mr. Felix Bruppacher.

MR. BRUPPACHER:

Mr. Chairman, ladies and gentlemen, I would like to take this opportunity to thank you very much for sharing our work and our experience, and to learn together with you here in this conference during our work on the region and the problems of water supply. It has been an impressive conference, and I only hope to see many of you next year in the International Conference of the IWSA in Switzerland. Thank you very much.

CHAIRMAN:

The delegation from Republic of China represented by Mr. L. C. Cheng.

MR. L.C. CHENG:

Mr. Chairman, distinguished delegates, ladies and gentlemen, in November 1979, the Second Regional Conference of Water Supply in Eastern Asia was held successfully in Taipei, capital of China. In high attendance of 247 participants from nine countries, we have achieved that exchange of knowledge, technological ideas and experiences in our involvement in water supply and to develop long time friendships. According to the detailed and completed preparation by the Philippine Water Works Association, there are much more participants to take part in this conference than ever before. In addition there are more than 20 exhibitions to display their appropriate products. Primarily, let me congratulate the organizers for the full success of this conference and wish all of you a good health and have a wonderful time. Thank you.

CHAIRMAN:

The delegation from Thailand, Mr. Suvich Futrakul. Mr. Suvich Futrakul

MR. SUVICH FUTRAKUL:

Mr. Chairman, laides and gentlemen, in behalf of the delegates from Thailand, I would like to extend our great appreciation to the Philippine Water Works Association and their Organizing Committee of the 3rd Asia Pacific Regional Water Supply Conference and Exhibition. Most particularly to the leadership headed by Mr. Oscar Ilustre, general manager of MWSS and Col. Carlos Leano, general manager of LWUA for having given us this opportunity in participating in the most successful and fruitful event. Thank you.

CHAIRMAN:

The delegation from USA, Mr. Aultman.

MR. AULTMAN:

Chairman Ilustre, fellow delegates, ladies and gentlemen and friends. In behalf of the delegates from the United States, many of whom registered as having come from the Philippines because, they have lived here for so long and they are working here and also on behalf of those representing the chairman of International Committee of the American Water Works Association, I like to express our gratitude, appreciation and indicate to how we feel for this conference which has been excellently prepared by Chairman Ilustre and Col. Leano. This is a conference that Mr. Hidayat will have a hard time to follow in Indonesia, two years from now but, I know he will succeed in doing that as well as what they have done here. I also like to indicate the desire of all of us the way we represent to continue to support the Philippine Water Works Association and the entire organization of this new Asia Pacific Organization, in any way we come to help you in every activity. Thank you.

CHAIRMAN:

There is a lady who does not indicate here her state or country. So, may we request Miss Sandra Watt to accept this certificate of attendance. There are additional certificates of attendance from Denmark, France, Germany, and Italy, we regret the delay. Is Denmark delegate here? The certificates of the delegates of the Philippines would be distributed later in alphabetical order. Our Chairman and president of PWWA will now give more remarks and announcement.

MR. ILUSTRE:

Fellow delegates, ladies and gentlemen. You have hit pressure on us and now it is my turn to hit pressure in you for coming and bearing with us for the last few days. Now, it is my honor to announce that we have agreed in the East Asia Pacific Board that the next site of this conference would be in Indonesia in 1983; the host nation will be in 1985. In Zurich in September of 1982 and in Indonesia in 1983; the date will be announced later. I will now give to Mr. Hidayat of Indonesia the gavel, because after tonight, he will start preparing for the fourth East Asia Pacific conference in Jakarta.

In the copy of the Resolution in a meeting held this noon, from among the chief delegates, we have agreed to create a Standards Committee with representatives from the various sectors of the water community for the purpose of submitting a draft to be confirmed in 1983. So this will be organized and we hope that we will come up with this East Asia Pacific standard. As I said before, using the standard of American, Europe is a little stiff for us, and we would like to stretch the little money that we have in time to lower the specification to suit our requirements. In most of our rural areas, we do not have the second story building. So, I think we can afford to reduce the pressure in the rural areas. The committee will come up with our own standards and if we have standards, I think that the manufacturers will have to follow so, may I give now the floor to the delegate from Indonesia, Mr. Hidayat and the vice-chairman present and from now on, he will bear now the shoulder of trying to make up for the fourth, whatever shortcomings we have from the third, we hope to recover in showing for the fourth Asia Pacific Conference.

MR. HIDAYAT:

Mr. Chairman, Oscar Ilustre, ladies and gentlemen. I arrived from Taipei to attend the conference as the head of the delegates. On the first evening I arrived in Manila, I did not expect that Indonesia will be offered to host the fourth water supply conference. So, at that time, I did not respond, because I did not dare to accept that offer, because, I did not have the authority to decide, but being encouraged by Mr. Ilustre, Mr. Ocampo, and our other colleagues from other countries, who attended that meeting that evening, the same evening, I sent a letter to our government in Indonesia. So, I received a telex from our government giving their agreement, then I passed on this agreement to Mr. Ilustre in his room and then, it was properly discussed during the lunch of the head of the delegates this afternoon and to have the agreement from other member countries. And here I am, gentlemen, standing as the host of the coming water supply conference in Indonesia. So, it was a very short and quick story. So in this occasion, I wish to thank all of you for entrusting us to host the fourth water supply conference in Indonesia. We feel indeed highly honored to be entrusted with this task but, on the other hand, we are now confronted with the hectic accomplishment to successfully carry out this forthcoming conference. At this moment, I cannot say anything, the only thing I can promise is that we will be doing our utmost efforts and to do the best we can to make the conference in Indonesia a very successful one. Since this is the first international conference of this kind that we have to conduct, we will much welcome any suggestion and all assistance in how to organize such a conference and to make it successful. In this respect, again we are very encouraged by Mr. Oscar Ilustre and Mr. Ocampo to guarantee me their full assistance for the organization of the conference in Indonesia. It is because of them that I dare to accept the hosting for the fourth water supply conference, ladies and gentlemen, I will not make my speech long. My only wish is to have your support and cooperation in order to make the conference in Indonesia in 1983 as successful as one that is being held here in Manila today. In conclusion, may I in behalf of Indonesian delegates and of myself to extend our congratulations to the Chairman and to the organizing committee and the exhibit committee and all the entire staff for the excellent preparation of the organization of this conference. I also would like to express to the government and to the people of the Philippines for their warm hospitality extended to us during such an important conference. Thank you.

CHAIRMAN:

Our chairman, Mr. Oscar Ilustre will now declare the session close and as soon as he does that, he will turn over the symbol of authority to our forthcoming chairman from Indonesia, Mr. Hidayat.

MR. ILUSTRE:

I will now declare the Third Asia Pacific Water Supply conference close and I am turning over the gavel to Mr. Hidayat. You are reminded that at 7:00 o'clock tonight, we have our Awards Night at the Manila Hotel, Fiesta Pavilion. Thank you.

A RESOLUTION BY THE CONFERENCE TO COOPERATE TOWARDS THE EVOLUTION OF UNIFORM DESIGN, CONSTRUCTION AND OPERATION STANDARDS IN WATER SUPPLY.

Rationale: The conference believes that in order to:

- Meet the increasing cost in both construction and operations,
- Enhance the water supply-affiliated industries,
- Provide for a speedier decision process in choice of standard,
- and finally, to ensure simplicity and appropriateness of the technology applied.

Resolution: Therefore the Conference hereby resolves:

a. To create a Standard Committee with representations from various sectors of the water community for the purpose of submitting a draft to be confirmed in the next Conference in 1983.

b. To solicit the cooperation of the member-governments for the purpose of legitimizing the standards and providing for its enforcement.

c. To empower the Secretary (General) of the Asia Pacific Group of IWSA to take the needed action to achieve the objective of this resolution.

Done this 18th day of November, 1981 at the 3rd Asia-Pacific Water Supply Conference and Exhibition in Manila.

MEMORANDUM OF AGREEMENT

INTRODUCTION

1. At meetings in Manila during the period 15-19 November 1981 under the chairmanship of Mr. Oscar I. Ilustre (Philippines) representatives of corporate members of the International Water Supply Association (IWSA) agreed to ask the Executive Board of the Association formally to approve the formation of an Asia-Pacific Group (APG) with the objectives and constitution set out below. The discussions were assisted by Mr. Maarten Schalekamp, Vice-President, and Mr. Peter Stott, Secretary-General.

OBJECTIVES & METHODS

2. The prime objectives of the Group are those of the IWSA namely:

   To encourage communication and better understanding between those engaged in the public supply of water, and

   To secure concerted action in improving knowledge of public water supply – technical, legal and administrative.

3. The Group intends to pursue those objectives by fostering communication among those engaged in public supply in the Asia-Pacific Region; by encouraging participation of the world water community in discussion of questions affecting the region; by developing the contributions of members of the Group to the World Congresses of IWSA; and by encouraging the development of IWSA by seeking to increase membership corporate, associate and personal.

4. Within the region the principal activity of the Group will be the holding of a regional conference every two years (in years when there is no World Congress of IWSA).

MEMBERSHIP

5. Each Corporate Member of the IWSA in good standing and in the Asia-Pacific Region shall be eligible to nominate a representative as a member of the Group. The Constitution of IWSA provides that a national organization representative of Water Supply interests in a particular country, not having interests conducted for profit or partisan purposes, may be eligible for admittance by the Board of IWSA as a Corporate Member.

6. To secure effective liaison and in accordance with the usual practice of IWSA, the President, members of the Executive Board from Corporate Members in the region and the Secretary-General of IWSA shall be ex-officio members of the Group.

CHAIRMANSHIP

7. The Group shall formally elect a Chairman to take office for a period of two years comencing at the closure of a regional conference. The sole nomination shall be by the Corporate Member selected by the Group as host country for the next conference.

8. The Group may elect a Vice-Chairman.

SECRETARY

9. The Group shall appoint a Secretary. The term of office for the Secretary shall be two years in the first instance. It may be extended thereafter at the pleasure of the Group but normally for not more than two further terms of two years each.

10. The Secretary shall be the Chief Adviser on an honorary basis to assist the Chairman of the Group; he shall maintain close communication until the Secretary-General of IWSA, deal with correspondence within the changes and keep the records of the Group. He shall be provided with facilities and other support by the corporate member in the country to which he belongs.

FINANCE

11. Regional Conferences shall be self-supporting and all direct expenses shall be covered by registration fees and donations (if any). The financial responsibility shall be assured by the host country.

12. For the time being the expenses of the Secretary shall be met by the national organization of his country. It shall be the intention of the Group to minimize Secretariat costs.

13. Should the Group wish at any time to establish a budget the method of securing contributions shall be reported to the Executive Board of IWSA. In such case the Secretary shall keep proper accounts and shall obtain contributions and spend moneys on behalf of the Group in accordance with such rules as may be stipulated by the Executive Board of the Group.

14. The Executive Board shall be composed of the Chairman, Vice-Chairman, Secretary and the immediate past Chairman. The Executive Committee shall be the heads of the national water supply associations.

TECHNICAL PAPERS

WATER SUPPLY DEVELOPMENT ACTIVITIES IN THAILAND

by VITHYA PIENVICHITR

Provincial Water Works Authority
Thailand

1. Introduction

The Royal Thai Government has already decided that Thailand will participate in the International Drinking Water Supply and Sanitation Decade.

This means that by 1991 all Thai citizens are supposed to have access to safe drinking water and sanitation facilities.

Taking this into account the timing of the established planning cycles in Thailand, the Thailand Safe Drinking Water Supply and Sanitation Decade will cover the 5th and 6th Five Year Development Plan periods, i.e., 1982-1986 and 1987-1991 respectively.

2. Present sector status and policy

2.1 *Urban water supply*

In Thailand, urban water supply sector comprises the following piped water supply sub-sectors.

i. Bangkok Metropolitan areas,
ii. Municipal areas, and
iii. Large Sanitary District areas.

2.1.1 *Bangkok Metropolis*

The Metropolitan Water Works Authority, MWWA, is responsible for the supply of water in the Metropolis. Approximately 70% of this population is served by the MWWA.

2.1.2 *Municipalities and large Sanitary Districts*

Recently formed Provincial Water Works Authority, PWWA, is responsible for all piped water supplies in urban areas outside of the Bangkok Metropolitan area. In the municipal and large Sanitary District areas, it operates about 190 water supply schemes. For other areas of the PWWA responsibility see 2.3 (vi).

The Provincial Water Supply Division, PWSD, of Public Works Department, PWD, is responsible for piped water supplies for which concessions were granted to the municipal authorities. For other areas of the PWSD responsibility see 2.3 (v).

It is estimated that the population served by the piped water supply systems is 60%.

2.2 *Rural Water Supply*

The responsibility for the rural water supplies in Thailand is shared by a number of organizations.

The National Economic and Social Development Board, NESDB, is entrusted with the coordination of work of organizations responsible for the rural water supply. In alphabetic order the major of these organizations are: –

i. *The Accelerated Rural Development Office,* ARD, operates in 56 provinces and in the sensitive areas. It constructs a. large diameter tube-wells equipped with hand-pumps; b. shallow dug-wells, not necessarily equipped with hand-pumps.
ii. *The Department of Community Development,* DCD, provides funds for self-help water supply projects. The safe water supply programme of the DCD mostly includes construction of sanitary shallow dug-wells equipped with hand-pumps, and dug-wells without the hand-pumps.
iii. *The Department of Local Administration,* DOLA, provides funds for the improvement of water supplies in areas not covered by ARD. These improvements can be implemented by other technical organizations, or by private contractors. It also supplies hand-pumps for the sanitary dug-wells. Where groundwater is not available it finances the installation of the rain water cisterns.

iv. *The Ground Water Division*, GWD, of the Department of Mineral Resources constructs large diameter tube-wells which are either equipped with hand-pumps, or with power operated pumps. This is the major large diameter tube-well drilling organization which also conducts the hydrogeological investigations and evaluation.

v. *The Provincial Water Supply Division*, PWSD, of the Department of Public Works constructs large diameter tube-wells which are either equipped with hand-pumps, or with power operated pumps. For another area of PWSD responsibility see 2.1.2.

vi. *The Provincial Water Works Authority*, PWWA, is responsible for the provision of piped water supplies in small Sanitary Districts and in those rural communities which can undertake operation and maintenance of such schemes. These are of present 650 piped water supplies of this type. These receive the technical support of the PWWA. For another area of PWWA responsibility see 2.1.2.

vii. *The Rural Water Supply Division*, RWSD, of the Department of Health, DH, is responsible for the construction of dug-wells, small diameter tube-wells equipped with hand-pumps, piped water supplies in communities with less than 2,000 inhabitants and water supply in hospitals.

viii. *The Sanitation Division*, SD, of the Department of Health, DH, is responsible for safe water supply to schools, temples, and health centres. These are small institutional supplies and are normally not used by the general public.

The SD is also responsible for safe drinking water programmes including construction of rain water cisterns and conversion into sanitary wells of the existing dug-wells which are used as drinking water sources.

It is estimated that at the end of 1976, 11.2% of the rural population had access to safe drinking water by measures other than piped water supply. This figure has been arrived at as follows: –

Population served

Agency	**Millions**	**Remarks**
ARD	0.525	
DCD		included
DOLA	0.200	in other
GWD	1.600	agencies
PWSD	0.497	
RWSD and SD	0.050	
Total	2.772	

Total rural population in communities smaller than 2,000 people was 24.7 millions.

3. National Sector Plans for the Decade

Planning for the Decade in Thailand is expected to become a process which will extend throughout the Decade, and beyond.

The planning work is undertaken by the organizations responsible for the subsectors and is coordinated by the National Economic and Social Development Board, NESDB. The NESDB is the national focal point in Thailand for the Decade.

The planning process will *generate* the implementation programmes for each sub-sector for two five-year development plans as follows: –

1st half of the Decade – 5th Five-Year Plan 1982-1986 (2525-2529 B.E.)

2nd half of the Decade – 6th Five-Year Plan 1987-1991 (2530-2534 B.E.)

The planning process will also formulate detailed project proposals.

The Preparatory and Planning Phase (198-81) is intended for the initiation of the planning process for each sectors, the preparation of the implementation programmes for the 5th Five-Year Plan, 1982-1986, and the formulation of detailed project proposal for at least the five year of the 5th Five-Year Plan, i.e. 1982.

3.1 *Urban Water Supply*

3.1.1 *Bangkok Metropolis*

The responsibility for the planning of the piped water supply in the Metropolitan area rests with the Metropolitan Water Works Authority, MWWA. The MWWA already has the long term plans, but it may be necessary to adjust these plans to coincide with the Decade.

3.1.2. *Municipalities and Large Sanitary Districts*

The responsibility for planning of the piped water supplies in these urban areas rests with the Provincial Water Works Authority, PWWA.

In the urban areas where piped water supplies are not likely to be developed during the Decade for economic reasons, the provision of access to safe drinking water will be planned as in the rural areas.

The responsibility for planning of piped water supplies in the municipal areas which hold concessions rests with the Provincial Water Supply Division.

3.2 *Rural Water Supply*

The multiplicity of organizations involved in the rural water supplies in Thailand makes the planning for the Decade in this sub-sector particularly difficult.

However, the results available so far from the pilot projects which were implemented during the earlier part of the Preparatory and Planning Phase suggest that two simple and inexpensive safe drinking water supply solutions can be implemented as a part of the Primary Health Care programme. 60% to 70% of the population may be involved. These solutions are: –

i. conversion into sanitary wells of all the existing dug-wells which are used as sources of the drinking water, supplemented where necessary by construction of rain water cisterns, and
ii. small diameter tube-wells equipped with hand-pumps in areas where hydrogeological conditions are suitable, but where dug-wells are not used as sources of the drinking water.

3.2.2.

The planning process for the rural water supplies will be arranged into a series of consecutive steps outlined below: –

i. survey in all the districts of the existing drinking water sources and of the existing methods of excreta disposal.
ii. identification of those areas where dug-wells, or dug-wells in combination with the rain water cisterns, are used as sources of the drinking water.
iii. identification of areas where hydrogeological conditions are suitable for small diameter tube-well equipped with hand-pump, but where dug-wells are not used as sources of the drinking water.
iv. identification of areas and communities where hydrogeological conditions may be suitable for the construction of high yielding tube-wells equipped with power operated pumps, but where dug-wells are not used as sources of the drinking water, and where communities can afford, or practically afford to support such schemes.
v. identification of areas and communities where solutions mentioned in steps ii. to iv. are not possible and where surface waters after adequate treatment have to be used as the drinking water supply.

The planning work outlined above will be carried out by the water supply organizations of the Ministries of Interior, Industries and Public Health, and will be coordinated by the National Economic and Social Development Board.

3.2.3.

In these areas of the Bangkok Metropolis, in the Municipalities and in the large Sanitary Districts which are rural in character and are therefore not likely to be served by the piped water supply systems within the foreseeable future, the planning approaches considered for the rural areas proper (see 3.2.2. above) will be applied.

The responsibility for planning of simple water supplies in these areas is divided as follows: –

i. Bangkok Metropolis-Bangkok Metropolitan Administration
ii. Municipalities-municipal authorities.
iii. Sanitary Districts-local authorities.

3.2.4.

In small Sanitary Districts and rural communities with population between 2,000 and 5,000 people, planning procedures considered for the rural areas proper (see 3.2.2 above) will be applied except in cases where communities are ready to accept the financial responsibility for the development, operation and maintenance of the piped water supplies. In such cases the responsibility for planning will belong in case of small Sanitary Districts and rural communities with less than 2,000 inhabitants to RWSD, and in case of communities with population between 2,000 and 5,000 people to PWWA.

3.2.5

To ensure the achievement of the objective to provide access to safe drinking water for all people of Thailand the Ministry of Public Health, MPH, is entrusted with the responsibility for the surveillance of water quality of all waters used for drinking and domestic uses in all the urban and rural areas. This surveillance is in addition to the operational surveillance of water quality carried out by the organizations entrusted with the responsibility for the production of safe water.

The MPH will undertake the necessary planning and programming of the necessary surveillance of water quality for the Decade.

4. Mobilization of resources

In Thailand, the philosophy which is being tried in preparation for implementation of the Decade can be summarized as follows: –

It is possible to be certain of the real acceptance by the people of the safe drinking water supply, sanitary excreta disposal and other sanitary measures only when people participate to the fullest possible extent financially and where applicable by contributing their own labour in the implementation of these measures.

Thus, the responsibility of the central government is expected to involve the overall planning and programming, health education of the population, training of implementors where necessary, ensuring the necessary internal and external resources, guidance and where it will be necessary assistance with the implementation, and evaluation and surveillance of effectiveness of measures used.

4.1 *Urban water supplies*

Generally, to achieve the objectives of the Decade in Thailand it will be necessary for the piped water supplies in the urban areas to be self financing.

4.1.1 *Bangkok Metropolis*

At present, the piped water supply in Bangkok Metropolis is in part subsidized from the national budget.

4.1.2 *Municipalities*

At present, piped water supplies in the municipal areas, in the Sanitary Districts, and in the rural areas are in part subsidized from the national budget.

4.2 *Rural water supply*

Until now, rural water supplies were generally developed with funds from the national budget. The maintenance of these schemes, although it is the responsibility of the communities, often receives financial support from the central government.

Recently, in preparation for the Decade, a new approach of financing simple water supplies has been tried and evaluated. In pilot projects of a district size all the existing drinking water sources have been identified. A programme of conversion into sanitary wells equipped with PVC hand-pumps of all dug-wells which are used as sources of the drinking water was implemented. The people are asked to express the approval of the proposed scheme by providing all the materials and labour necessary for the conversion. People appear to be ready to make this contribution. The inspection of all implemented schemes indicates that most of the schemes are in operation and that people do maintain and when it is necessary repair the hand-pumps.

It is intended to try this approach of direct people participation in the more sophisticated systems i.e., small diameter tube-well equipped with hand-pump.

The financial participation of the population is considered essential for the achievement of the Decade's objectives. It is realized that in addition to the very important fiscal considerations such participation will ensure that the proposed scheme fills the local need, because it is unlikely that people will put their own money into a scheme which does not meet their requirements and priorities.

4.3 *External Resources Sought*

Although increasing emphasis is being placed in Thailand on the reliance on country's own financial and technical resources, it is becoming evident that to achieve the Decade's objectives Thailand will need financial assistance and technical cooperation from both the bilateral and the international sources.

At the same time, Thailand is ready to share with countries which will participate in the Decade the results of its own work in the fields of safe drinking water.

5. Conclusion

The provision of drinking water supply in Thailand can be divided into 3 levels, i.e.,

i. The Bangkok Metropolitan Area, which is operated by the Metropolitan Water Works Authority;
ii. Other municipal and large sanitary district areas, operated by the Provincial Water Works Authority, and
iii. The rural areas, which cover about 75% of the total population with 8 different agencies operating under various ministries.

Considerable improvement has recently been accomplished in the piped water supply sector. The Metropolitan Water Works Authority is at present implementing its Master Plan to serve all people within the Metropolis and the first phase of improvement has been completed. A new Provincial Water Works Authority has also been established responsible for the planning and implementation of the ruban water sector, while the National Economic and Social Development Board will give special attention to the development of an integrated plan for the rural water supply sector.

Source: "Country Report for International Drinking Water Supply and Sanitation Decade," National Economic and Social Development Board, Bangkok (1980).

THE WATER SUPPLY DEVELOPMENT IN TAIWAN IN THE EIGHTIES

by YUNG-JI KOU

Sub-manager of Planning Department
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1. The Environmental Status of Taiwan

Taiwan is about 36,000 Km^2, an island outside of the Chinese Mainland, and Northeast to the Philippine Island. It has a sub-tropical marine climate. During summer and autumn seasons, the marine air mass creates convective storms and typhoon precipitations. The average rain is 2430 mm per year, and is 874 hundred million cubic meters in total. About 80% of the rainfalls in summer and autumn. Spring and early summer are dry seasons.

The administration of Taiwan is divided into three parts: the province of Taiwan and the districts of Taipei and Kaohsiung. Because of the 3000 m high Central Mountain Ranges running through north to south, there are only 25% of plains along the seashore with the western parts wider, and the eastern parts narrower, the rest are mountain areas. The rivers run along the mountain. The rivers are short with sharp slopes so the river water is scarce in dry season. If we want to utilize river water to meet the needs of water supply service, we have to build dams.

2. Past Development of Water Supply in Taiwan

Since the water supply system was first built in the year of 1896, the work developed continuously in Taiwan. In 1973, there were 281 water supply systems managed by 130 waterworks, with 2,090,000 CMD in total capacity, to serve 7.6 million people – 49% of the total population. In 1974, those 130 Waterworks were emerged to two management agencies. Taiwan Water Supply Corporation (TWSC) and Taipei Water Department. Then, the development of Water Supply in in Taiwan became much faster than ever.

At the end of the year 1980, the number of the water supply systems were emerged to 212, and the total capacity increased to 4,674,000 CMD. The population served was increased to 13.4 millions and the rate of the population served was 75.3%

3. The Relationship of the Factors Affect the Water Supply Development in Taiwan:

The water quantity needed for each capita always varies with the climates, customs, and environment. But the population growth and the economic development have stronger influence on the water supply service. If the population served increases, the necessity of the water supply service increases, too. And owing to the improvement of the economic situation, the population served, family sanitary equipments, and the ideas of hygiene, the customs of using water supply service vary. Therefore, the relationship of these factors: the total population, the urban population, gross national product, average income per capita, population served by water supply, the rate of growth of population served and the water supply capacity, between 1960 and 1980 are analyzed below.

According to the Attachment 1, the yearly growth rate of the total population in Taiwan was decreased from 3.3% in 1960 down to 2.1% in 1971. It pointed out that the family planning had its great result in this period. From 1972 up to 1980, the population yearly growth rate was between 1.96% and 1.81%, except the years 1976 and 1979, during which periods, the yearly growth rate was over 2%. There was no significant tendency of the decrease of the population growth rate, which meant that the family planning still did not affect much of the basic ideas of people's desire to have more children.

This tendency might last for a while. As for the economic growth, the average people's income was US $358 in 1960, which was raised up to US$1318 in 1980. Except the year 1974, the growth of the increase rate was influenced by the international energy crisis, which had the sense of negative value, the rest of the increase rate had the positive value, the average increase rate was US$48 per year. Please refer to the Charts I to III which are the explanations of Attachment I. Chart I shows the relationship of the water supply population, the city population, and the total population. Since 1974, the increase rate has become steady. It shows that there were more budgets and definite policies for the water supply business, and the condition of the family planning also became steadier. In 1978, the population served by water supply overpassed the city population. Apparently the water supply development reached the remote villages.

Chart I

THE GROWTH OF THE POPULATION EXPRESSING WITH TOTAL, CITY AND SERVED

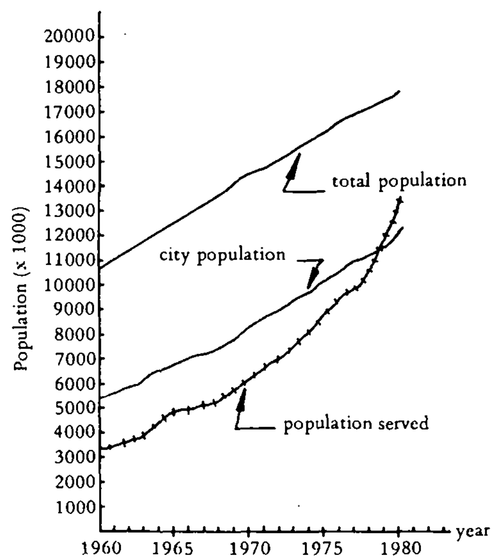


Chart II shows the comparison of the sum of the yearly growth of the total population, the city population and population served. It is obvious that the curves which show the city population and the total population go steady, when the curve which shows population served goes unsteady, before 1974. Then the curve goes steady after that year, and gradually surpassed both of the another two.

Chart III shows the relationships of the yearly increasing rate of economic growth, the total population, and the population served. The curve which shows the sum of the yearly increasing rate of gross national product is sharper than the curve which shows the income per capita, expressing that part of the national products were thus consumed by the higher increase rate of the population. After 1974, the curve of the water supply capacity goes up sharply. The water supply service thus reached both the domestic and the industrial customers. The tendency of the growth of the yearly increase rate of the population served shows the efforts of the people in the water supply business and the support of the government department.

CHART II

SUM OF THE VARIOUS INCREMENT OF POPULATION GROWTH

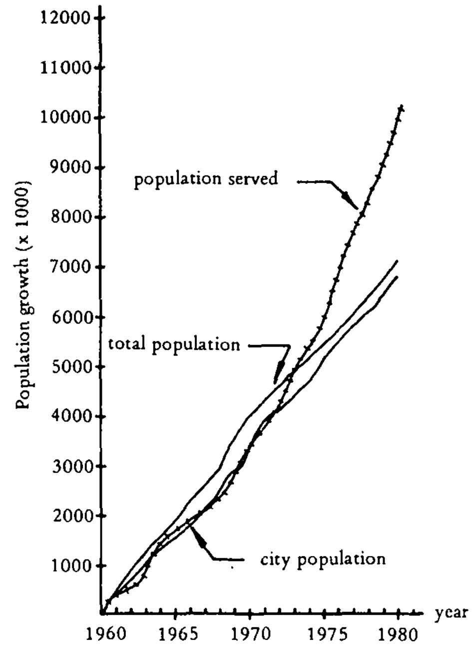
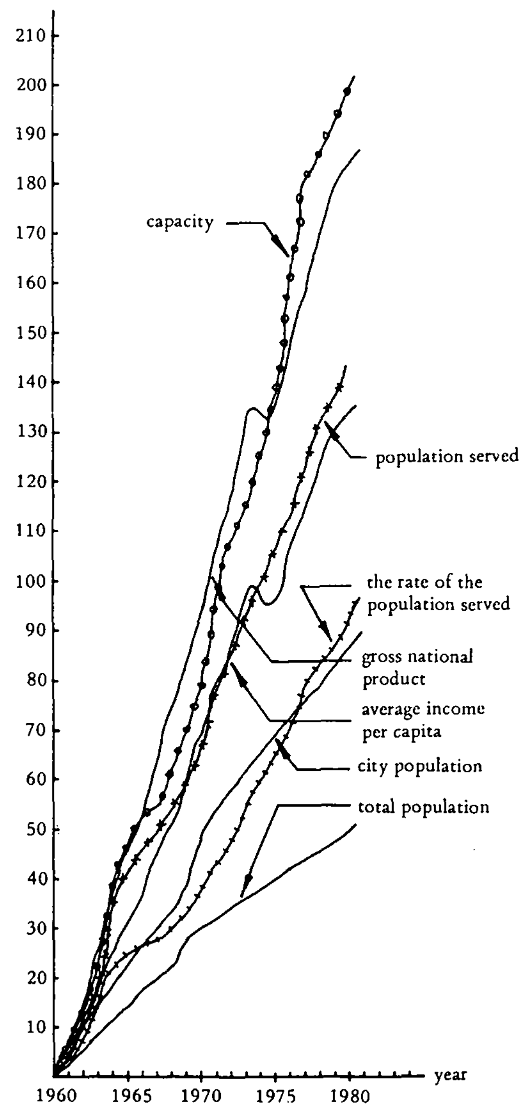


CHART III

SUM OF THE PERCENTAGE OF YEARLY GROWTH



4. Water Supply Development of Taiwan in the Eighties — a General Plan

Owing to the steady growth of the economy and the higher standards of the compulsory education, the problem of drinking water is deemed important. Up to the end of 1980, the rate of population served was 92% in the district of Taipei. A general view of the water supply service for the other areas was made as fellow list:

Table 1

Classification of community (persons)	Total Numbers: Community	Total Numbers: Population	Served Area: Community (x1000)	Served Area: Population	Served Area: %	Unserved Area: Community (x1000)	Unserved Area: Population	Unserved Area: %	Note
Over 10,000	130	6,315	126	6,184	98	4	131	2	The rate of population served was calculated according to the population of those community served so it is higher than the actual
2501-10,000	620	2,825	573	2,482	88	74	343	12	
501-2500	2928	3,692	2,269	2,466	67	659	1226	33	
201-500	1756	628	1,212	355	57	544	273	43	
beneath 200			1,823				1823	100	
total	5434	15,283	4,184	11,488	75	1250	3585	25	

According to the above list, the populations of the communities with rather low rate of water supply service were the community with population under 2500. Thus in the 80's the government set the goal of the development, to expand the water supply systems in those areas. For instance, in order to solve the problem of drinking water in Hsiao Liu-Chiu which is a small island with 16000 population, in July of this year T.W.S.C. finished a submarine pipeline from Lin-Pien, at the southwest of Taiwan. The pipeline is 200 mm inner diameter, with 14.1 km length. And it will supply drinking water 3000 m^3 per day with total investment more than US$ 5 million.

Since most of the natural sources of water have been used, and owing to the economic growth, the needs of water supply service in both of the economic growth, the needs of water supply service in both of the industrial and the public use have become more urgent. The only way to meet the problem is to expand the water supply systems and build more dams. (It will take about ten years to construct a dam from planning up to finishing.)

At present, to develop more water resources is an urgent goal in the water supply business.

To sum up, a general plan for water supply development in Taiwan in the eighties is as follows:

1. To continue the increase of the rate of population served: The future needs of the water supply service should be according to the results of the industrial growth, and the increasing population served. It should be estimated according to the overall and individual analysis. And research should be done according to the government policies, and the decisions of the administration of water supply service. A list of goals of water supply development in the eighties is as follows:

Table 2

YEAR	Total Population (x 1000) (1)	Rate of Population (%) (2)	Population Served (x1000) (1) x (2) = (3)	lpcd (4)	Capacity (X10000CMD): Public (3) x (4) = (5)	Capacity (X10000CMD): Industrial (6)	Capacity (X10000CMD): Total (5) + (6) = (7)
1980	17,805	75.3	13,411	284	3,808	866	4,674
1985	19,247	82.8	15,936	337	5,378	1,741	7,119
1990	20,715	86.3	18,230	384	7,000	2,560	9,560

The water supply development for the general public and that for the industrial use are estimated separately. Recently, the water supply for the industrial use is 14.5% – 19.6% of the total water supply. The rate was highest in 1978, which reached 19.6%. Later on the water supply for the industrial use increased, but the rate is lower. It points out that the industrial growth is slower than the increase of the water supply. This should also be taken into consideration.

The water supply development was first done in the areas where there were larger communities with economical water resources and investment. The developments later on were rather difficult. The estimate for the later development was getting higher yearly. It needs about 13 hundred million U.S. dollars for the coming ten years.

The goals to increase the rate of population served for the following ten years are as follows:

a. Population served: In 1990, the planned population served will be 18.2 million. It will be 4.8 million increase compared to the 13.4 million in 1980.

b. Rate of population served: 86.3% in 1990. 11% increase compared to 75.3% in 1980.

c. Water Supply Capacity: 9.6 million CMD in 1990. 4.9 million CMD increase compared to 4.7 CMD in 1980.

d. Investment: 13 hundred million U.S. dollars in 1990, according to the indices of prices in May, 1981.

2. Plans for developing water resources: At the end of 1980, the water supply capacity in Taiwan was 3.3 million CMD. In 1990, the need of water supply capacity will be 9.6 million CMD. For meeting the increasing water supply capacity demand, the only way is to build dams, though we may get a little amount which now is for the agricultural use. Four dams will be finished before 1983, with an investment of US$1.2 million. Another five dams, which are being planned now, will be finished before 1991, with the investment US$15.5 million.

3. To improve the present water supply systems and its management: At the end of 1980, the water supply population and the capacity were increased 54 and 123%, respectively, compared to those in 1973. The number of the water supply systems became 212, a 25% decrease since 69 systems were joined. There was one system whose water supply capacity was over one million CMD and which produced 1.2 million CMD.

There were 8 systems whose water supply capacity was 100,000 – one million CMD, totally, 2.3 CMD.

There were 33 systems, with water supply capacity reaching 10,000 – 100,000 CMD each, totally, 880,000 CMD, 84 systems, with water supply capacity reaching 1000 – 10,000 m^3/day each, totally, 310,000 CMD and 86 systems with water supply capacity reaching under 1000 CMD each, totally, 30,000 CMD. In order to raise the quality of the water supply, to decrease the man power, and to meet the situations of constructing dams, the small systems should be unified, gradually in the future, though we have to put much more investment. For the past eight years, owing to the improvement of the water supply systems, the manpower needed for every 1000 CMD water supply work was decreased from 3.25 persons in the end of 1973 down to 1.69 persons in 1980. The average decrease rate was 6% per year. From now on the water supply service will further develop in the remote small community, therefore the decrease rate of the manpower, which getting from the improvement of the equipments, and the unification of the systems would be slower.

The manpower requirement of about 1.5 persons for every 1000 CMD water supply capacity in 1990 is the goal.

The modernization of the water equipment, and the enlargement of the service won a good reputation and much encouragement for the personnel in the water supply business. They worked harder and were more successful year after year. There are some points which will be strengthened as time goes on:

(a) To improve the management: to continue to improve the present systems, and the management so as to make it an enterprise.

(b) To raise the sold supply water rate and to better the water supply quality: at present, the sold supply water rate is 75%, and will be 80% in 1990. Thus, the leakages should be repaired immediately, and the pipelines should be changed when necessary. More equipment should be provided in order to check up the quality of the water supply, to make sure that the water is not polluted in the delivery pipelines, so as to supply clean drinking water to the customers.

(c) Computerized: To equip computers in the filtration plants and the water delivery pipeline systems, record and store the information, for checking and analyzing the management systems in order to save natural resources and manpower.

(d) Emphasis on the service to the customers: Aside from providing necessary service in the aspects of water quantity and water pressure to meet the needs of the customers, other aspects of services should be provided, too.

(e) Personnel training: to provide for personnel training programs constantly so as to have the people trained and in order to raise the standard of the quality of service to the customers.

5. Conclusion

1. The stability of the society and the growth of economy are the stepping stones for the water supply development. Water supply development in Taiwan in the early period was checked by the Second World War. Especially at the end of the war in 1944, water supply equipments were destroyed. They were recovered after five years of reconstruction after the war. Later on, because of the social stability, the rapid growth of the economy, the higher living standards, and the better ideas of hygiene, the needs for water supply service became urgent. The rapid growth of economy made the government capable in guiding the various businesses to make further development. In Chart III, it is easy to see the close relationship between the economic growth and the need of water supply. Since 1960, the economic growth became steady and the populations in the cities grew along side by side. water supply development, thus, gained the same rapid progress.

2. The influence of the government policy on the water supply service: In 1974, the government set up a long range plan for the development of water supply service. It provided a definite guidance. Therefore, the rate of population served, the water supply capacity, and the population served, grew up to meet the necessary of the society as time went on. This can be easily discerned in charts. Thus, the water supply business makes further development and wins the social recognition. This owes much to the correct policy of the government.

3. The increase of the rate of population served will become more difficulty as time goes on: Since the natural water resources have been fully used, it will cost much more to develop new water resources, and since the water supply service has reached all the places where it is easier to provide the service and where the areas are heavily populated as shown in table (IV-1). The further water supply service will aim at the places where the community population are under 2500. Because these villages are largely scattering around the mountains, it is harder to get the water resources and to set up the water supply systems. The cost for the water supply development is rather high. Therefore starting the eighties, the increase of the rate of population served only reaches 1.1% per year. It can not be discussed at the same time with the increase of the water supply rate within the last seven years, 1974-1980, during that period, the average increase per year was 3.8%.

Attachment 1: **POPULATION AND WATER SUPPLY IN TAIWAN**

year	total population			city population			gross national pro.		average income per capita		population served			rate of population served		capacity (CMD)		investment	note
	total	yearly growth	rate of yearly growth	total	yearly growth	rate of yearly growth	total	rate of yearly growth	total	rate of yearly growth	total	yearly growth	rate of yearly growth	total	rate of yearly growth	total	rate of yearly growth		
	(x1000)	(x1000)	(%)	(x1000)	(x1000)	(%)	(x1000)	(%)	(US$)	(%)	(%)	(x1000)	(%)	(x1000)	(%)	(%)			
1960	10792	–	–	5419	–	–	4232	–	358	–	3202	–	–	29.67	–	690	–	1652	
1961	11149	357	3.3	5681	262	4.83	4511	6.59	370	3.51	3430	228	7.12	30.77	3.71	737	6.81	1080	
1962	11512	363	3.26	5982	301	5.30	5917	9	391	5.51	3592	162	4.72	31.20	1.39	802	4.88	1963	US$1
1963	11884	372	3.23	6272	290	4.84	5488	11.61	423	8.22	3884	292	8.13	32.68	4.74	802	3.75	1085	=NT$
1964	12257	373	3.14	6608	336	5.35	6236	13,63	467	10.48	4574	690	17.76	37.32	14.19	1019	27.05	2998	38
1965	12628	371	3.02	6865	257	3.89	6700	7.44	489	4.64	4839	265	5.79	38.32	2.68	1082	6.18	842	
1966	12993	365	2.89	7186	321	4.67	7329	9.39	521	6.46	5018	179	3.70	38.32	0.78	1155	6.74	2057	
1967	13297	304	2.34	7348	162	2.25	8125	10.86	561	7.79	5192	174	3.50	39.05	1.11	1155	0	3530	
1968	13650	353	2.65	7652	304	4.13	8881	9.3	597	6.44	5460	268	5.16	40.00	2.43	1261	9.18	6289	
1969	14335	685	5.02	8183	531	6.94	9801	10.36	643	7.65	5900	440	8.05	41.16	2.90	1384	9.75	5301	
1970	14676	341	2.38	8679	496	9.72	10931	11.53	699	8.79	6350	450	7.63	43.27	5.13	1519	9.75	8253	
1971	14995	319	2.17	9036	357	4.11	12306	12.58	770	10.05	6840	490	7.72	45.78	5.80	1786	17.57	13555	
1972	15289	294	1.96	9341	305	3.37	13962	13.46	856	11.14	7350	510	7.46	48.07	5.00	1982	10.97	10097	
1973	15565	276	1.81	9697	356	3.81	15555	11.41	941	9.97	8041	691	9.40	51.66	7.47	2094	5.65	9725	
1974	15852	287	1.84	10050	353	3.64	15210	- 2.21	906	- 3.68	8503	462	5.75	53.64	3.83	2332	11.36	39644	
1975	16150	298	1.88	10550	500	4.97	15840	4.14	919	1.37	9110	607	7.14	56.41	5.16	2702	15.86	76176	
1976	16508	358	2.22	10945	395	3.74	18318	15.64	1039	13.06	9989	879	9.65	60.51	7.27	3339	23.57	105288	
1977	16813	305	1.85	11241	296	2.7	20089	9.67	1110	6.84	10942	953	9.54	65.07	7.55	3891	16.53	96180	
1978	17136	323	1.92	11498	257	2.91	22507	12.04	1218	9.79	11665	723	6.61	68.07	4.59	4082	4.91	42473	
1979	17479	343	2	11833	335	2.91	24175	7.41	1287	5.67	12322	657	5.63	70.49	3.55	4347	6.49	49544	2
1980	17805	326	1.87	12419	586	4.95	25256	4.47	1318	2.40	13411	1089	8.84	75.32	6.85	4674	7.52	59025	
Average	–	351	2.53	–	337	4.51	–	9.41	–	6.81	–	510	7.47	–	4.81	–	10.22		

WATERWORKS DEVELOPMENT IN JAPAN (National Report)

by OSAMU TANAKA

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1. Legal Systems Concerning Waterworks

It is in 1885 that the first modern waterworks was started to be built in Japan mainly for the purpose of preventing water borne diseases prevalence. And in 1890, the first law concerning waterworks was established in order to promote their proper construction.

The law stipulated that waterworks shall be built by a municipality in principle and provided some necessary procedures when waterworks are to be built. As time passed, it became necessary to conform the legislation to meet the needs of new situations along with the development of waterworks. In 1957, today's Waterworks Law was established after all-out revision of the old one.

In short, Waterworks Law. . .

(a) categorizes waterworks into 'Public Waterworks' to meet the demand of general public, 'Bulk Water Supply Systems' to provide public waterworks with purified water, 'Private Waterworks' and 'In-Building Private Waterworks with Receiving Tanks' and prescribes necessary provisions about each type of waterworks,

(b) prescribes that, as requested by local public entities, the governor of prefectures shall establish a long-term master plan about waterowrks within a certain area,

(c) establishes water quality standards and design criteria which every waterworks is subject to,

(d) prescribes that in principle local public entities shall manage public waterworks and bulk water supply systems, and that when they establish public waterworks or bulk water supply systems and modify their plans, their facility and management planning must be authorized either by the Minister of Health and Welfare as to large scale ones or by a governor of prefecture as to small scale ones, and

(e) obligates each public waterworks body, bulk water supplier and private waterworks manager to have a technical manager, under whose supervision the facilities and water quality must be properly managed and maintained.

2. Financial Systems Concerning Waterworks

Public waterworks and bulk water supply systems in Japan are managed on a self-paying basis in principle. That is, new construction and extension of waterworks facilities are financed by loans from the government, Financial Corporation of Local Public Enterprizes and private banking organs, and water charges are collected from water consumers to pay back the yearly installments as well as to maintain the systems. However, in order to promote waterworks extension to rural areas with small communities where high water charges are anticipated, central and local governments are subsidizing the construction.

Furthermore, recently, the government subsidizes water resources development such as dam construction and intermunicipal waterworks construction, because they require so much investment preceding their outcome that it proves to be impracticable for municipalities to afford it on a self-paying basis.

Waterworks management on a self-paying basis, as well as people's desire for hygienical living environment, has been promoting the rapid waterworks construction because it is free from budgetary limitation of the government and local public entities.

3. Waterworks Development and Public Health Improvement

In 1900, waterworks supplied water to only 3% of Japan's total population. After that, the percentage constantly went up to about 20% in 1925 and to about 35% in 1950. Later, especially through the economic development in 1960's, it rapidly climbed up to 53.4% in 1960, 76.9% in 1970 and 91.0% in 1979.

Public health aspects of waterworks turns to be quite significant. Along with construction of waterworks, number of patients of gastrointestinal infectious diseases such as cholera, dysentery, typhoid fever, paratyphoid fever, gradually decreased. In particular, after 1960 when waterworks became available for 50% of Japanese population, the patients decreased rapidly, namely from some 100 thousand patients in around 1960 to some 2,000 in 1975.

Obligated by Waterworks Law, maintenance of 0.1 ppm free chlorine (or o.4 ppm combined chlorine) in tap water must have also greatly contributed to the prevention of the diseases.

In this connection, hygienical education should not be overlooked as a background of recent rapid construction of waterworks and improvement of public health, while the rules of health in daily life has been instructed as a subject of compulsory education at school, each prefecture has carried out enlightenment activities to improve health consciousness among general public by establishing health centers for each 100 thousand people.

4. Status Quo and Confronting Problems of Waterworks

(1) *How to extend Waterworks to the Unserved Areas*

In 1979, 91.0% of total Japanese population are using waterworks. The problem from now on is how to extend waterworks to remaining 9.0% people. Since these areas are oftenly mountainous and sparsely inhabited, some countermeasures are necessary in order to solve their problems such as high costs for construction and maintenance of the facilities.

(2) *How to Get Water Resources*

In Japan, the amount of water distributed by waterworks was 13.8 billion m^3 in 1979, or 364 and 469 as daily average and daily maximum per capita, respectively. Because water demand in regional cities is and will be significantly increasing, water resources development, particularly dam construction must be promoted.

(3) *How to Assure Safety of Water Quality*

Bacteriological danger to potable water was solved by chlorination practice in waterworks systems. However, various pollutants in raw water still pose prolbem. Among them, pollution by heavy metals is being much improved by strengthening water pollution control. Instead, micropollution by organic chemicals such as organochlorinated compounds has become the problem lately. Monitoring of these substances and research and investigation of such as their long-term effects on man's health are the problems to be solved from now on.

(4) *How to Strengthen Technical and Financial Basis of Waterworks*

In order to cope with financial problems such as rationalization of investment of water resources development and construction of other facilities, equalization of water charges, and technical problems such as development of water quality control, it is necessary to regionalize as many as 18,000 waterworks, and by so doing, strengthening of their technical and financial basis must be achieved.

A NEW APPROACH OF WATER SUPPLY DEVELOPMENT IN INDONESIA

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I. INTRODUCTION

Indonesia is one among the nations which has very fast growing especially after second world war.

Population was recorded 118 million in 1971, and this figure reach, over than 140 million in 1981.

Population increase is estimated between 2,3 to 2,5% per annum. The archipelago stretchs from West to East at the distance approximately 6,000 kilometers, extedning between 95° – 141° East latitude, and from 6° North to 11° South latitude.

In fact Indonesia is volcanic region, mountainous, partly covered by dense forest.

Moonsonal winds which circulate Back and forth from the Asia and Australia continents gives strong affect to the climate of this country.

Average rainfall is about 1,000 mm a year.

II. ADMINISTRATIVE, DIVISIONS

Administratively, the country is divided into 27 Provinces, each province or each Territory divided into "Kabupaten" (equivalent of regencies), there are 260 "Kabupaten" and each regency (Kabupaten) administers some districts and villages. There are +3,000 districts and +40,000 villages in all over the country.

Which are administered by Province or regencies according to their size, to those which has independent administration are called Kotamadya (Municipal cities).

III. PRINCIPLE PROBLEM ON WATER SUPPLY IN INDONESIA

In the past, the mean of providing of water supply in the most cities in Indonesia was to supply the small group of the people whom had distinguished social status. The rest of the people remain with traditional supply from dugwells, river water, rain water and others mean of supply.

Facilities were built, since the year of 1900, and for this limited supply it can easily understood that the facilities were gradually decrease from year to year.

There was no exact data on the facilities of water supply before 1950, so far it is recorded that the facilities was available only in the big cities.

In 1969, it was recorded that water supply facilities is available in 50 cities, serving approximately 30% of their inhabitants (+ 6 mio out of 18 mio) either by house connection or public tap. The ratio of people served by house connection or public tap was estimated as close to 1:2.

From the statistic to day it is shown that the coveragetion in urban reas is +20% (that mean decrease of service as compare to 1969 service) of population served and in rural area only 16% of population was served.

The major problem are:

– The big number of population.
– Short of fund.
– Short of man power.

Basically the problems are similar as found in other developing countries.

The technical standard has to be improved, some consultant engineering firms start to have special division in their company, offering their service in sanitary engineering field. But for large scale projects it still rely to get technical assistant from foreign company.

Contractors:

Plenty of contracting or general contractor whom operate in different field of engineering, but relatively small number of the contractor who specially offer their service for water supply construction as compare to the demand available. In this case the Government initiates the training on technical and management for building the water supply facilities (covering the civil works, pipe laying methods and others which relating to the major works of water supply projects).

Materials & Equipment:

Pipes made of many different materials; factories for asbestos cement, P.V.C., galvanized steel pipe; and the recent product is GRP (glass fiber reinforced pipe).

Fitting and other accessories also produced locally.

Practically pipes as major supporting material can be produced locally.

Water meters start to produced by Government Institute in Bandung (I.I.N.).

IV. PROJECT IMPLEMENTATION.

Prior to 1969, several new water treatment plant were built to serve those cities which had the most serious water problems, (Jakarta, Bandung, Surabaya, Semarang, Pontianak, Medan, etc.).

Production capacity increase 100% as compare to pre-war condition, but distribution capacity did not increase accordingly due to lack of funds. Major source of funds for construction was born by central Government and secondary mains and distribution net work was left to the municipalities. This arrangement of development did not give the optimum result in term of utilization coverage. In 1969, Government start entering the 1st five-year development program (1969-1974) and water supply programme was also include under sectoral program.

During 1st five-year development program (known as PELITA I), Government of Indonesia has the goal to increase the production capacity from 9,000 1/sec to 17,000 1/sec. It was recorded that at the end of the 1st, PELITA only 80% of this goal was achieved so that in 1974 only 16,000 1/sec. were theoretically available. Again we noticed that the coverage was not increase accordingly due to lack of fund; the distribution net works improvement was less satisfactorily and the additional number of people served was very little.

At the PELITA II the services reach to 12,000 1/dt, that mean by 1979 the average consumption was +20/cap.1.day. The implemetnation continued with the target of production 3,000 1/sec. by 1984. By this amount of facilities it is hoped to serve 60% of total population by consumption of 60 1/cap per day.

V. BUDGET

The budget was born from different sources among others:

1) Government fund.
2) Loan, grant and donors fund.
3) Self-generating fund.
4) Others (Banks, International institution, etc.)

The budget involve in accordance to the program of water supply are as follows:

A. URBAN :

PROGRAM & TARGET	BUDGET
1. PELITA-I (1969 - 1974) 68 cities / 15.480 l/sec.	Rp. 11.952.100.000,- ≈ $ 19,123,360
2. PELITA-II (1974 - 1979) 98 cities / 20.545 l/sec.	Rp. 51.288.300.000,- ≈ $ 82,061,280
3. PELITA-III (1979 - 1984) 399 cities) 1.700 IKK) 30.000 l/sec.	Rp. 342.081.400.000,- ≈ $ 547,330,240
T o t a l	Rp. 405.321.800.000,- ≈ $ 648,514,880

B. RURAL :

PROGRAM & TARGET	BUDGET
1. PELITA-I (1969 - 1974)	Rp. 872.350.000,- ≈ $ 2,770,000
2. PELITA-II (1974 - 1979)	Rp. 20.000.000.000,- ≈ $ 48,000,000
3. PELITA-III (1979 - 1984)	Rp. 31.000.000.000,- ≈ $ 75,000,000
T o t a l	Rp. 51.872.350.000,- ≈ $ 125,770,000

VI. NEW APPROACH ON WATER SUPPLY DEVELOPMENT, IN INDONESIA

Looking to the large scale of water supply demand in Indonesia, the Government felt that new approach should be introduced as such to speed up the development of water supply in Indonesia.

The basic consideration are as follows:

a) Serving of potable water to the people is not relating to economic capability of the people. Therefore the Government should take care the development of water supply either in urban area or in rural area in which the economic situation for those community are different from one to another.
b) 80% of population who lived in rural area is considered as a potential number in view of national stand point. Therefore their environment should be improved either directly or indirectly. In the case of water supply it is consider as the basic need to improve the environment.
c) By those two basic considerations, and with all constrains available, technically and financially, the department of Public works come with new approach as follows:
   1. The water supply scheme should spread equally in all over the country.

2. The cost per capita should eliminate to meet larger coverage.
3. The consumption per capita should be lower to increase the coverage.

The constrain on this approach are:

1) Time lacking.
All sequences on the implementation period should reduce drastically. This cover the planning, design, tendering and construction period.
2) Constrains on administration procedures.
Those are covering such as land acquisition, rights, water rights, working permits, legal aspects, etc.
3) Technical Standard.
Engineering approach should change to eliminate the technical standard to meet the minimum requirements.
4) Constrains due to limited technical informations.
5) etc, etc.

But, by any how the project has to start, therefore "total approach" should introduce as such that all activities should made simultaneously.

By this challenge, the Government of Indonesia come with two major programs out of regular/normal program of water supply scheme. Those are:

1) *Package Plant Program.*

This program covering 50 of 60 cities with packaged treatment plant (with standard to 10, 20 and 40 1/dt), which is start in fiscal year of 1980/1981, and follow with another 60 cities which is start in fiscal year 1981/1982.

This project is planned to be finish and operate with in the period of 2 years.

2) *I.K.K. Program.*

I.K.K. is stand for "Ibu Kota Kecamatan" which mean "the district center" or similar.

It is program in fiscal year 1981/1982 that 400 IKK will start. The program is covering 1,700 IKK which is planned to be finished within 3 years out of 3,500 IKK available in all over the country.

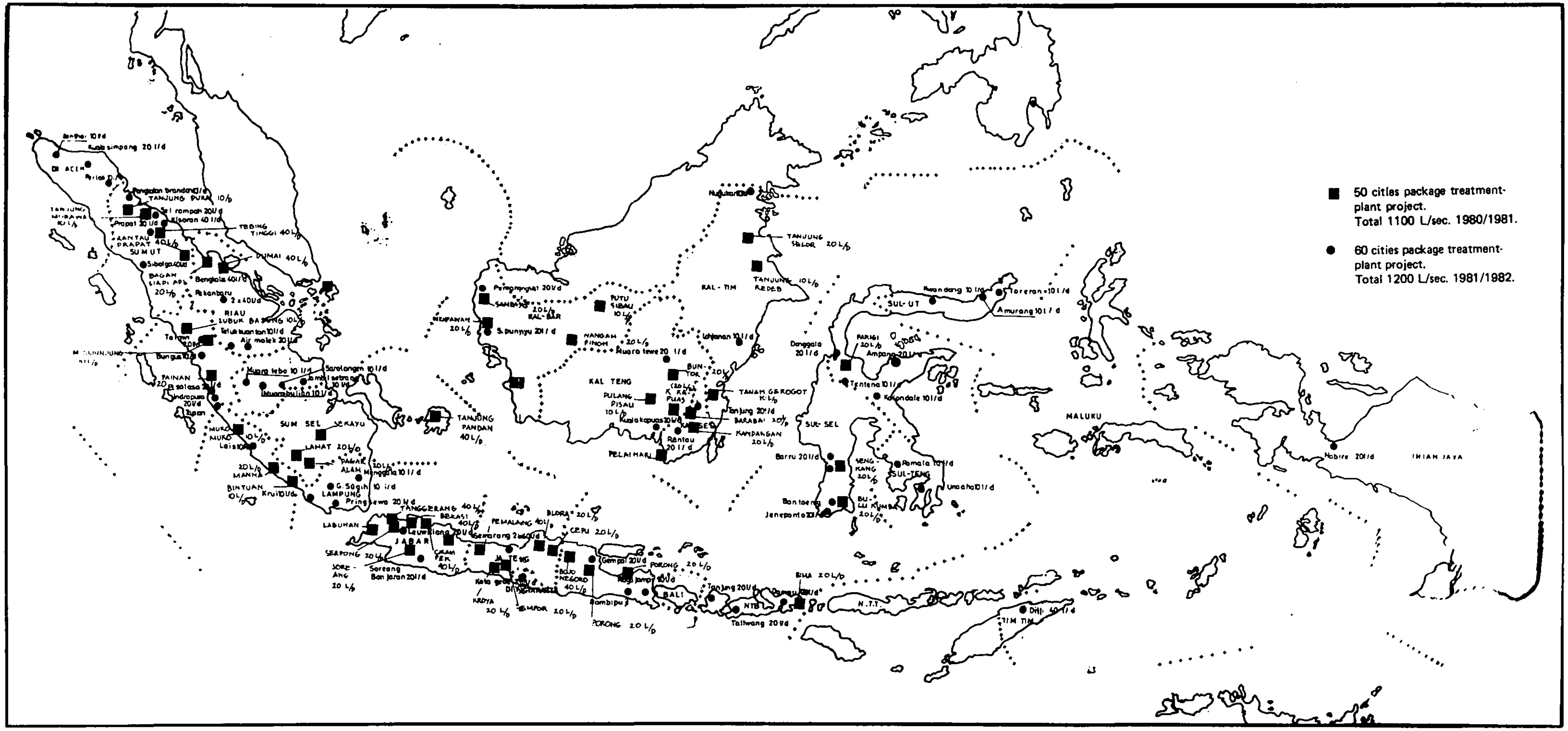
The complete description on this program is in annex.

DISTRIBUTION BY SIZE OF COMMUNITY

Urban Places	No.	Population (1 000)	of which in cities & municipalities
Less than 10 000	31	185	
10 000 - 20 000	57	1 230	30
20 000 - 30 000	32	671	52
30 000 - 50 000	49	1 799	169
50 000 - 100 000	44	2 901	1 001
100 000 - 200 000	18	2 643	2 240
200 000 - 500 000	6	2 113	2 113
500 000 - 1 000 000	3	1 865	1 865
over 1 000 000	7	7 334	7 334
	247	20 742	14 803
Rural Places (1971)	**No.**	**Population (1 000)**	**% Distribution**
Less than 1 000	9 846	6 053	6
1 000 - 2 000	9 791	12 101	12
2 000 - 3 000	10 184	24 694	25
3 000 - 4 000	8 891	27 571	28
4 000 - 5 000	1 388	6 561	6
5 000 - 8 000	3 947	20 968	21
over 8 000	53	459	1
	44 100	98 407	100
Total		119 150	

Source: Directorate of Hygiene and Sanitation, Ministry of Health,

All figures rounded
Only rough estimates



50 cities package treatment-plant project.
Total 1100 L/sec. 1980/1981.
60 cities package treatment-plant project.
Total 1200 L/sec. 1981/1982.
SUMUT
RIAU
SUM SEL
LAMPUNG
JABAR
KAL TENG
KAL-TIM
KAL SEL
SUL-UT
SUL-SEL
SUL-TENG
MALUKU
IRIAN JAYA
BALI
NTB
N.T.T.
TIM TIM

IBU KOTA KECAMATAN WATER SUPPLY IN INDONESIA
ELABORATIONS ON "STRATEGY AND SCOPE"

I. INTRODUCTION

Indonesia is planning to provide a large number of subregency capitals (Ibu Kota Kecamatan or IKK) with water supply systems in the near future. The basic principles of these plans were laid down in Cipta Karya's 2nd draft of the "Strategy and Scope of the IKK Water Supply Programme in Indonesia", dated May 27, 1981. The supply level is planned to be 60 lcd, all in, but to 60% of the population only. Translated into standard capacities this becomes:

* 2,5 1/sec system for population 3.600 – 7.200
* 5 1/sec system for population 7.200 – 15.000
*10 1/sec system for population 15.000 – 20.000

The water should supplied for roughly 50% through private connections and 50% through public taps.

Total construction costs for the supply systems should be low.

US$ 40/capita for systems with treatment plant
US$ 30/capital for systems deep wells
US$ 20/capital for systems with springs.

II. SOCIO-ECONOMIC ASPECTS

An average of 60 1/c/d all included becomes available. When supply is limited to such a level, the outlet points should be carefully designed to ensure compatibility between water demand and supply capacity. But also, there should be willingness and ability to pay for water thus provided.

2.1. *Private connections, public taps and affordability*

The willingness and ability to pay can almost exclusively be found through private connections: providing water inside the house for bathing, clothes washing, cooking, drinking, etc. Similar individual faciltiies are presently built by higher income families, where the possibility exists at reasonable cost.

The total demand for a private connections in Indonesia, for houses fully provided with water for bathing, toilet, clothes washing, etc. can amount to 150 1/c/d or more, gives the consequences a high monthly water bills.

If the same system would be applied for low income group living in a large number of small villages will increase not only the project cost but also doubt the affordability for the people to pay their monthly water bills.

To compare the monthly water bill for several level of supply Table 2.1. are given for a system with treatment, and a capacity of 5 1/s.

Table 2.1.

Supply level 1/c/d		ratio %	monthly bill/fam Rp		number of connections	
hc	pt	hc / pt	hc	pt	hc	pt
60	30	50 / 50	1125	400	360	18
75	30	33 / 67	1490	400	240	24
100	30	21 / 79	2300	400	155	28

hc = house connection
pt = public tap

The monthly bills corresponding with a high supply level of private connections could not be afforded in IKK's. Consequently, a minimal supply level of 60 1/c/d is recommended with a supply level for public hydrants of 30 1/c/d and a connection/hydrant ratio of 50/50.

2.2. *Compatibility of capacity and demand*

From the above can be concluded, that the supply level to public hydrants can only be 30 1/c/d. This implies, that water from the hydrants should be mainly used for drinking and cooking.

The private connections shall not be equipped with extensive plumbing or multiple taps. It is proposed that private connections receive an inflow constant over the day, and that buffering over the day is done by a private "bak mandi" with a minimal volume of 250 1 or other type of facilities having the same capacities.

III. LOW COST SYSTEM

3.1. *Standard system*

Three standard water supply systems have been adoped with production capacities of 2.5 1/s, 5 1/s and 10 1/s covering a population range of 3600 – 20000 people.

Since fixed numbers of people will be served, water allocations are pre set for each system.

The three systems have equally the following characteristics:

a. completely decentralized storage
   – at public taps in 3,5 m3 tanks (see fig. 1.1.)
   – at house connections in 280 1 bak mandi combined with 21 1 clear water tanks (see fig. 1.2.).

b. outflows at supply points are restricted to average water consumption level on maximum day.
   – public taps, 4,6 1/min.
   – house connection 0,46 1/min

c. two types of flow restrictions can be applied
   - pressure dependent flow restrictions of which different sizes have to be used for as well public tap as house connection according to pressure zones in the system.
   - pressure independent flow restrictions of which only one size has to be used for public taps and one for house connections independent of the location in the distribution system.

d. water distribution will be 24 h per day

The reduced supply level and the idea of using "private bak mandi" and storage reservoir in each public tap will bring the peak hour demand to a factor of 1 and to give a considerable reduction in per capita cost; down to the target level of US$20–$40 per capita.

3.2. *Design criteria*

Provided that 30 1/c/day is supplied to public taps and 60 1/c/day to house connection, and considering a ratio of 50%/50% for people served by public taps and house connections, and provided that also some water is allocated for other consumers (5%) leakage and losses (15%) and maximum day (10%), the number of people which can be served can be summaries: Table 3.1. with standard water allocation in table 3.2.

A summary of the design criteria adapted for the project are given in Table 3.2.

Table 3.1. Populations served by standard systems

Design horizon	1985							
Standard production levels 1/s	2,5			5			10	
Design populations served	3600			7200			14400	
Range target populations	3600	5000	7200	7200	10000	15000	15000	20000
Design populations served as % of target populations	100	72	50	100	72	48	96	72

Table : 3.2 Water allocation standard system

Standard production levels 1/s		2,5	5	10
Public taps	m3/d	54	108	216
House connections	m3/d	108	216	432
Total domestic		162	324	648
Non - domestic	m3/d	8	16	32
Leakage and losses	m3/d	25	51	102
Total average day	m3/d	195	391	782
Total maximum day	m3/d	216	432	864

Table 3.2. Design criteria low cost water supply systems

Items	Criteria	Remarks
1. Supply level public taps	30 1/c/d	
2. Supply level house connections	60 1/c/d	
3. Population served	60% or more	Initial target
4. Ratio population served by public taps and population served by house connections	50% /50%	Initial standard
5. Water allocation for non domestic demand	5%	Of domestic demand
6. Water allocation for leakage in the system and production losses	15%	Of total demand
7. Peak factors for maximum day	1,1	
8. Peak factor for maximum hour	no	decentralized storage
9. Design group for public taps	200 c/unit	
10. Design group for house connections	10 c/unit	

IV. SCOPE AND PROJECT COST

Within the third five years development plan the Government of Indonesia plants to build 1700 IKK. spread all over the country with staging of the development as follows.

*First stage year : 1981 / 1981 – 400 towns
*Second sate year: 1982/1983 – 600 towns
*Third stage year: 1983/ 1984 – 700 towns

This development will be continued in the next five years development plan to cover 3500 IKK. throughout the country.

4.1. *Implementation stage I:*

The implementation of the first stage development is further phase into 4 phases as follows:

phase I – 57 IKK.
phase II – 123 IKK.
phase III – 120 IKK.
phase IV – 100 IKK.

Item of activity for the implementation can be detailed as follows.

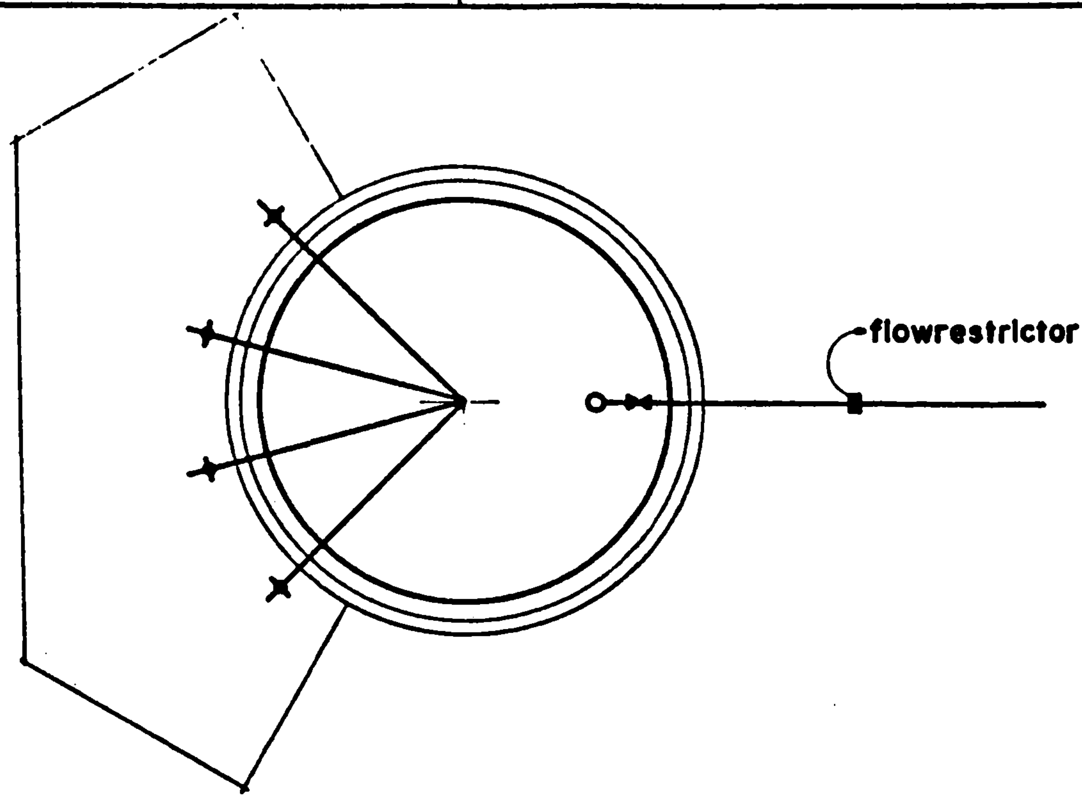
1° Project Preparation
2° Pipe & pump and other facilities procurement
3° Treatment Plan, spring capping, deep well development
4° Operation & maintenance

4.2. *Project Cost.*

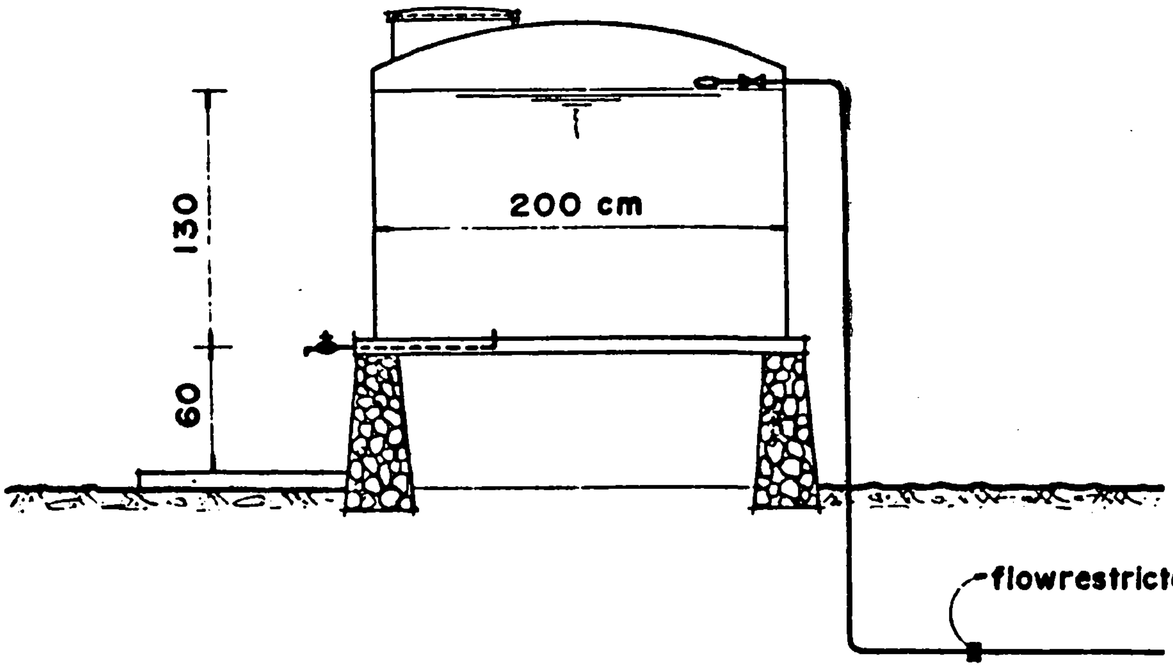
The first project implementation will be funded entirely out of local fund to a total amount of Rp. 51, billion.

This Project cost was calculated base on simplicity approach as the above mentioned discussion.

PUBLIC TAP	FIGURE 1.1.

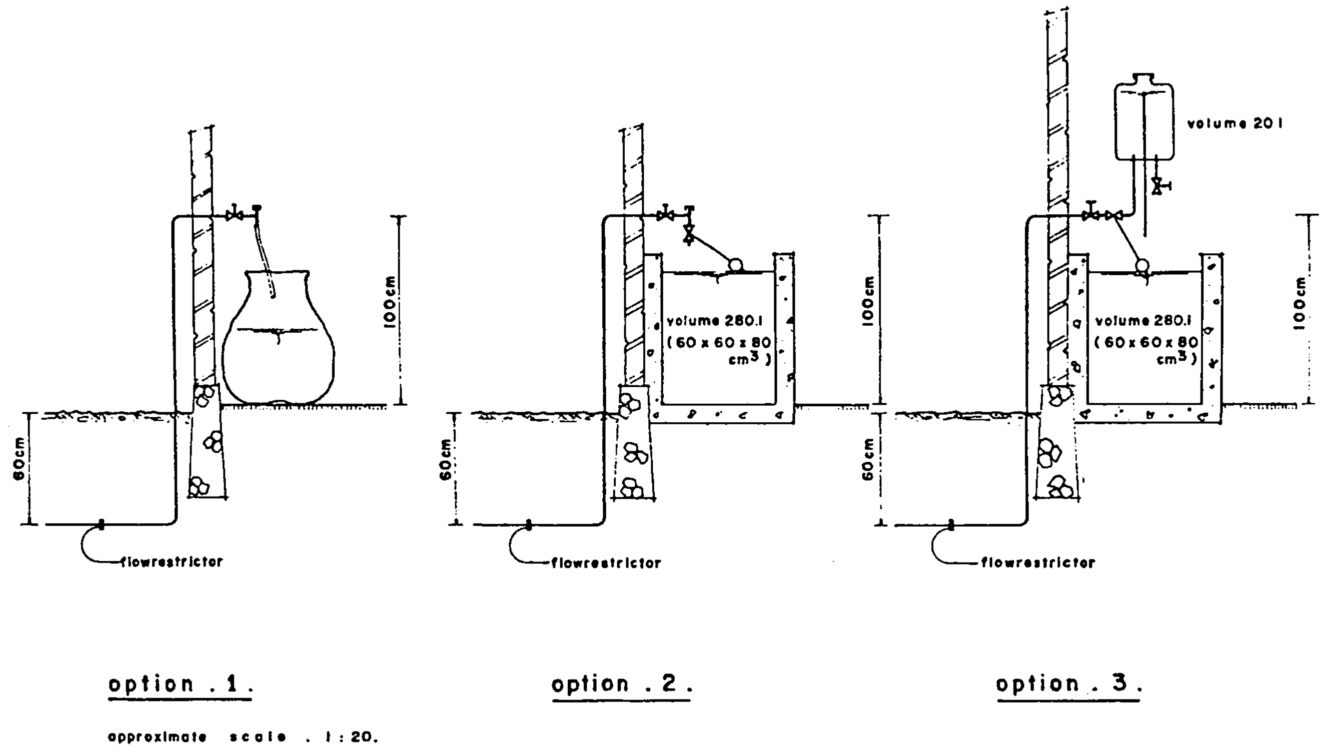


TOP VIEW

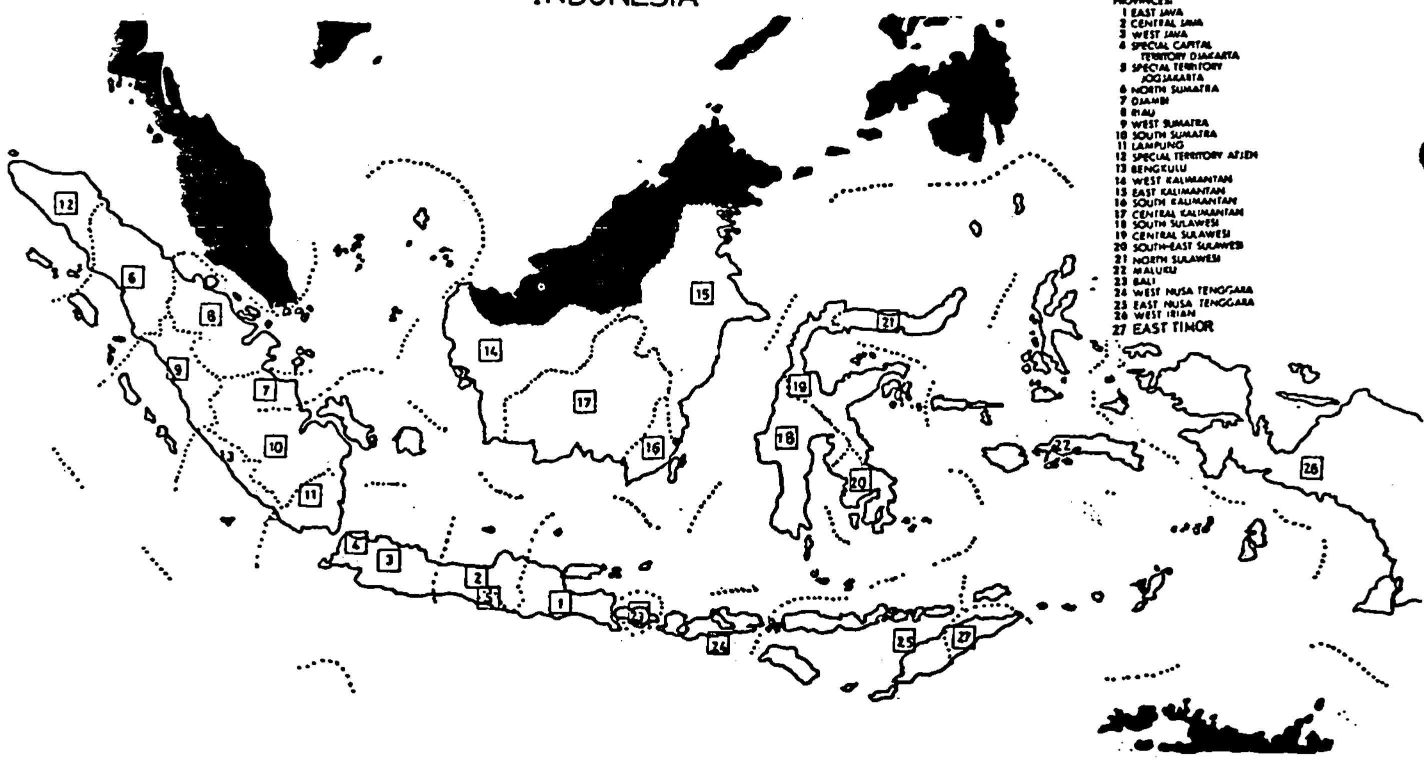


SIDE VIEW
Approximate Scale.1:40

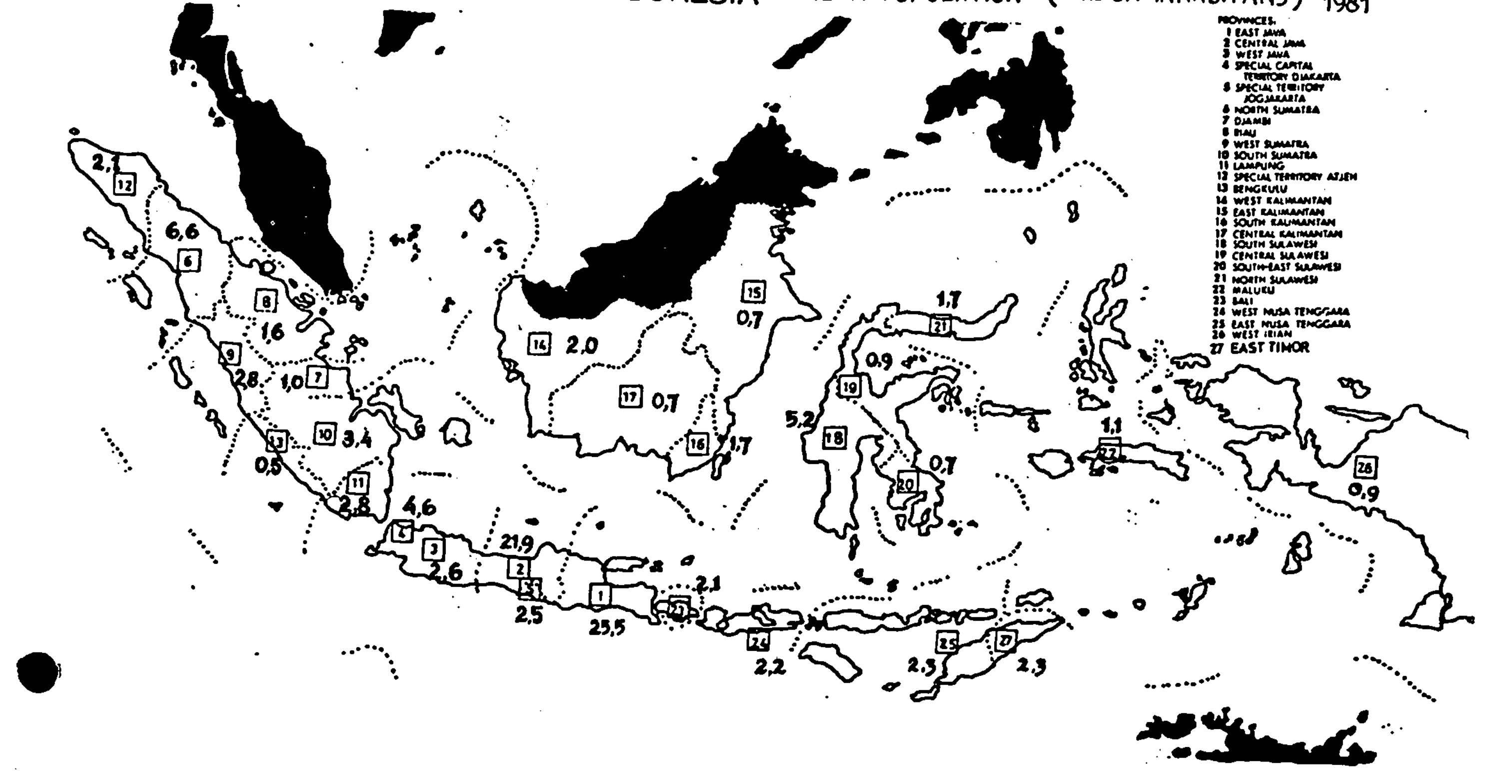
HOUSE CONNECTIONS | FIGURE . 1.2.



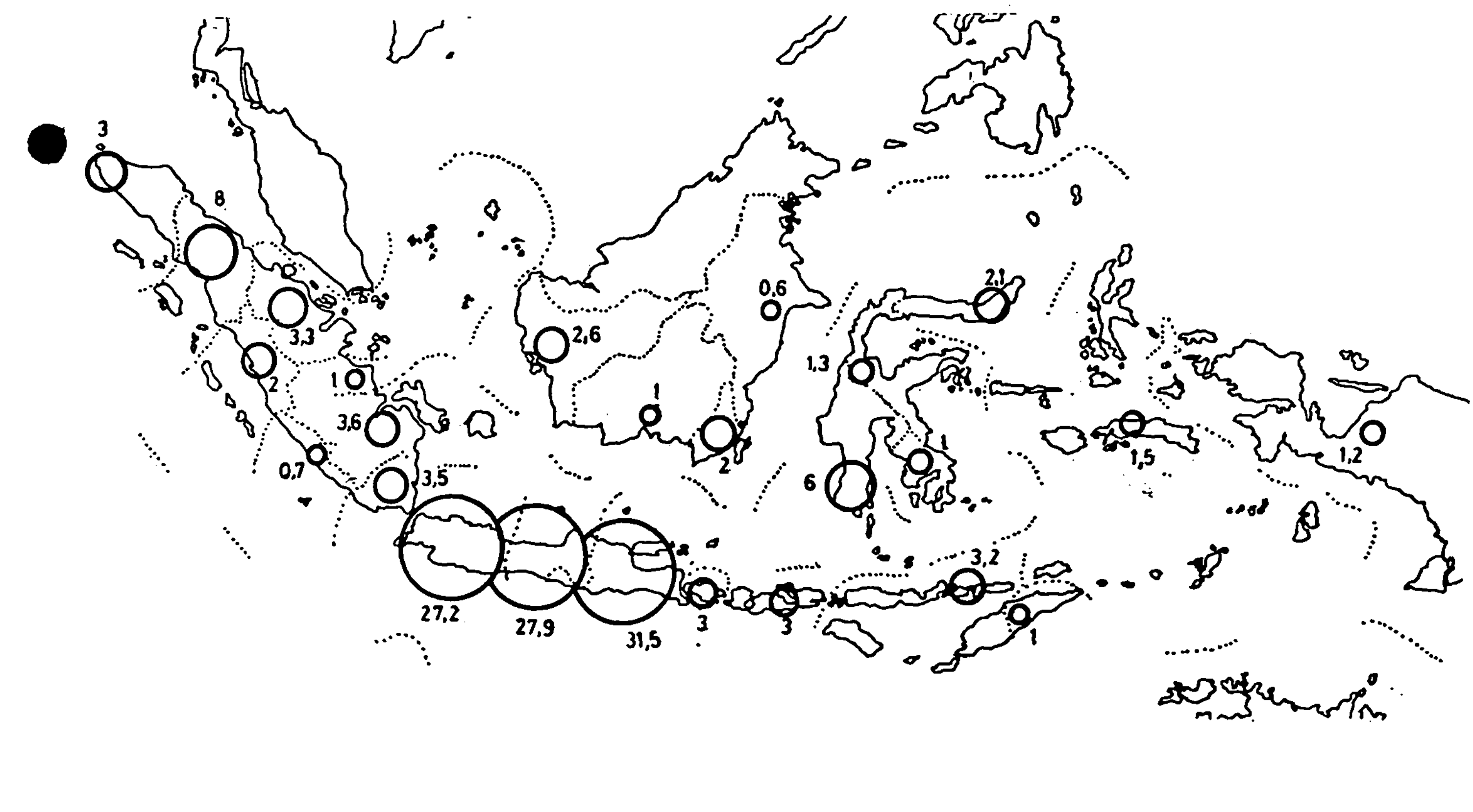
INDONESIA



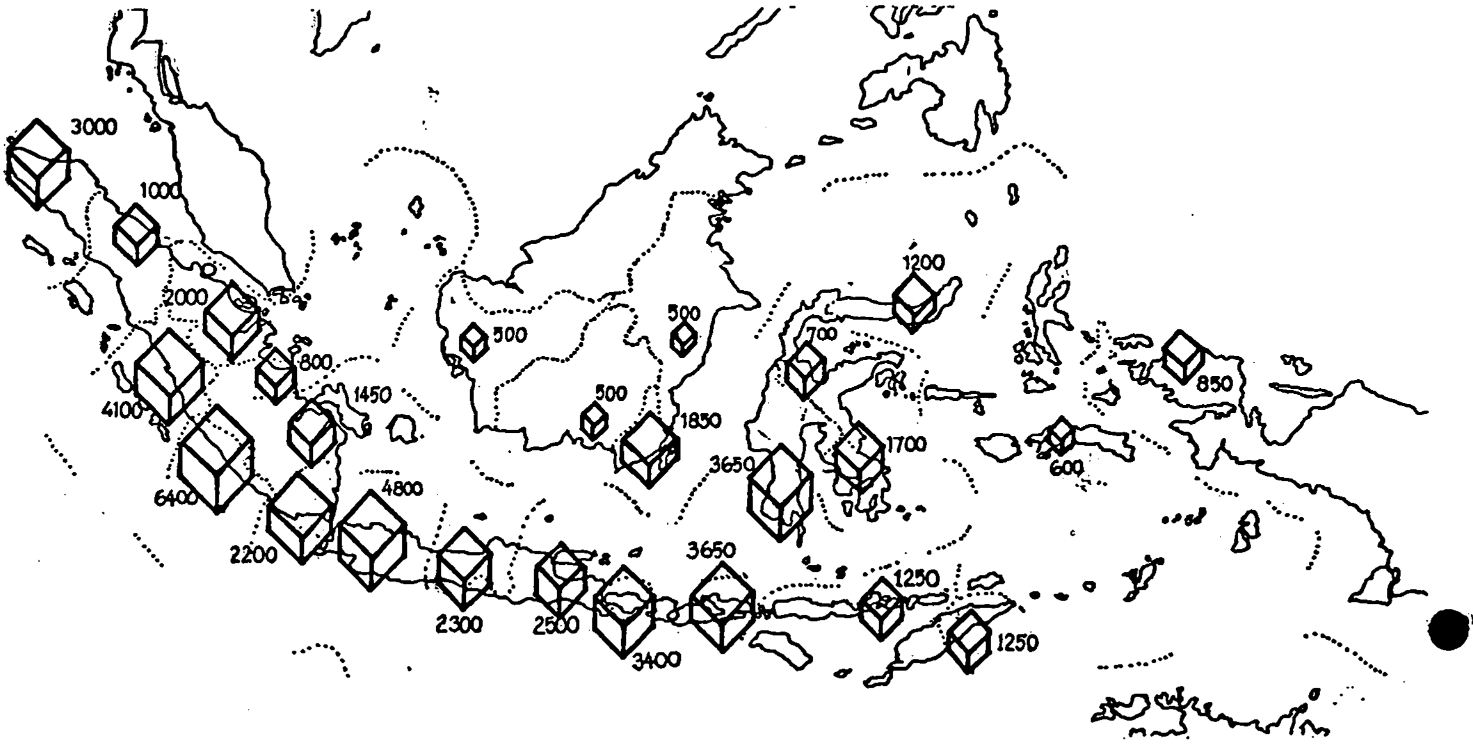
INDONESIA URBAN POPULATION (MILLION INHABITANS) 1981



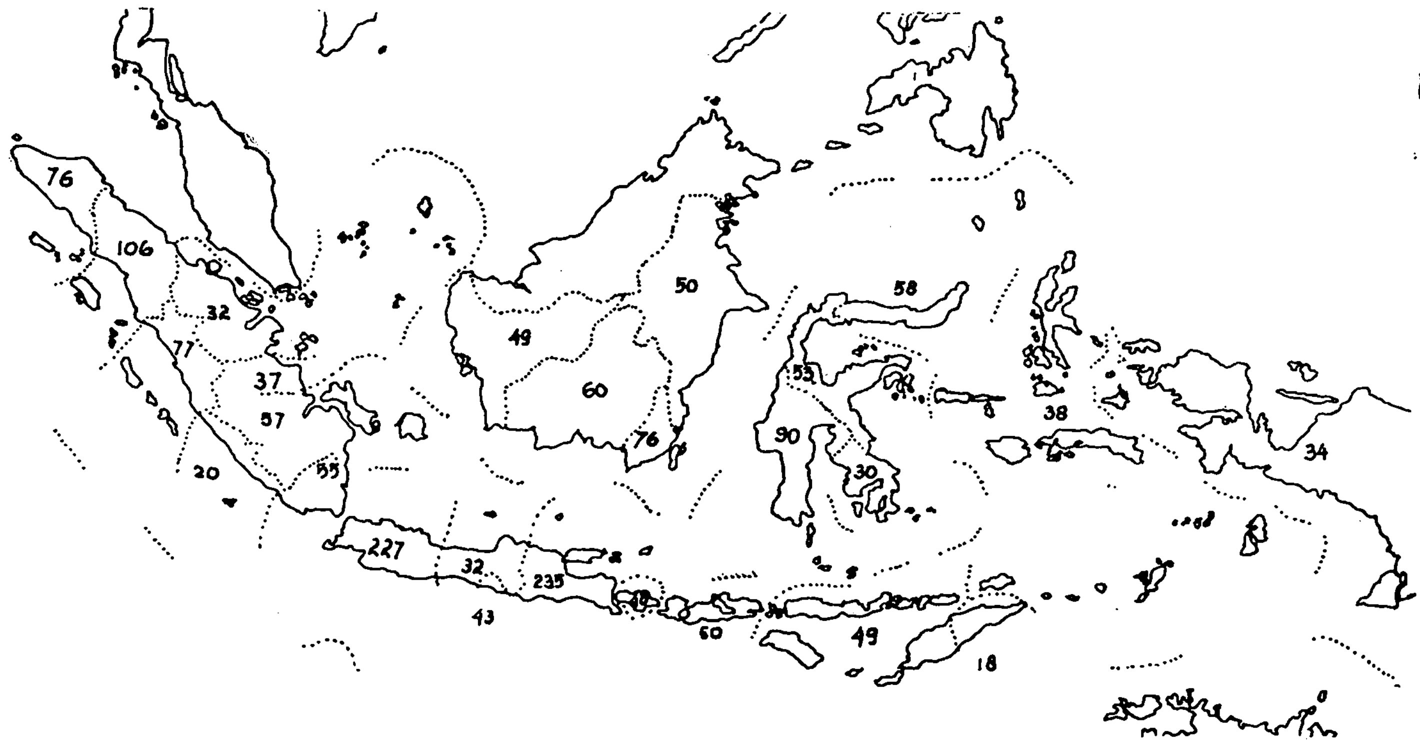
INDONESIA - RURAL POPULATION (MILLION INHABITANTS)1981

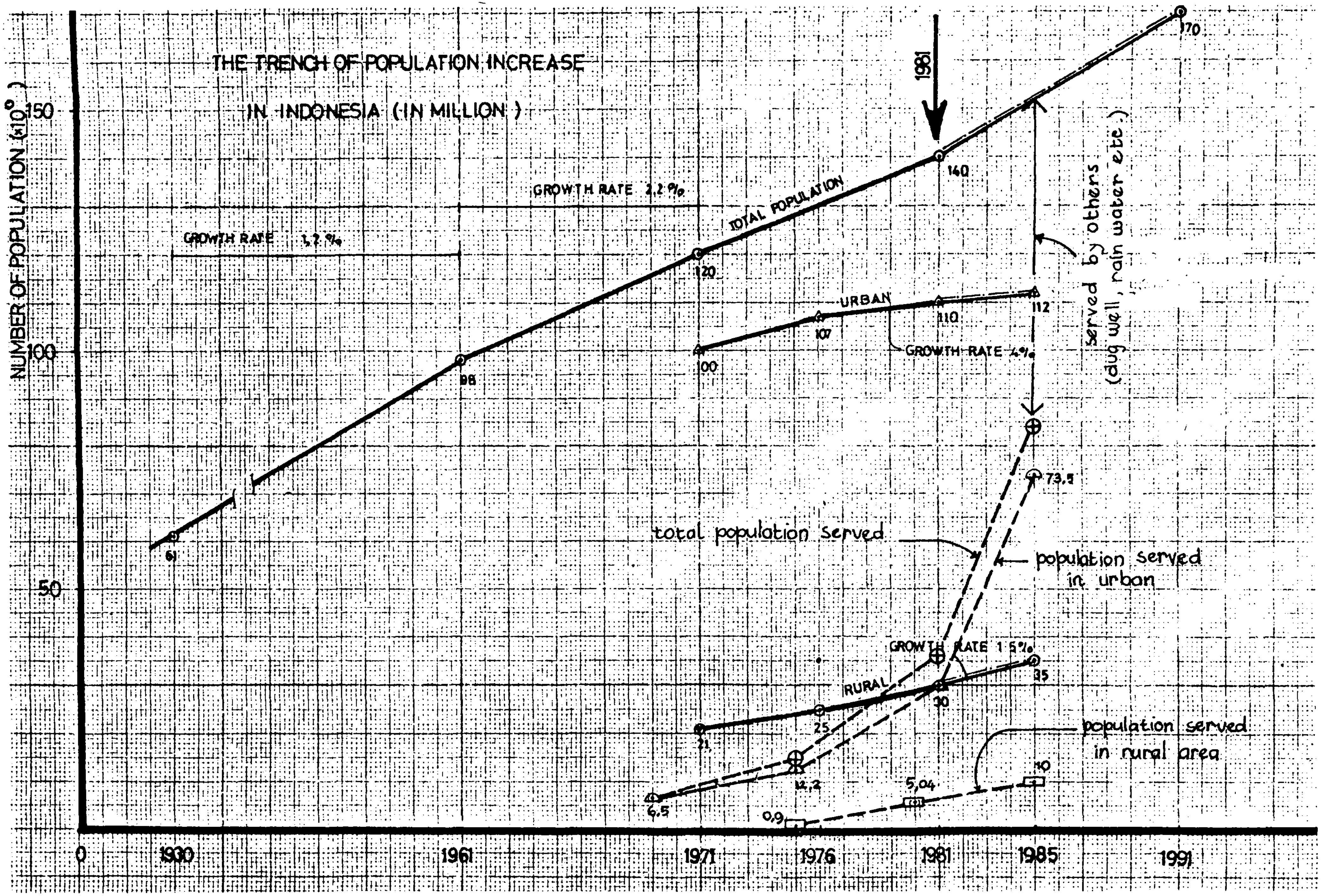


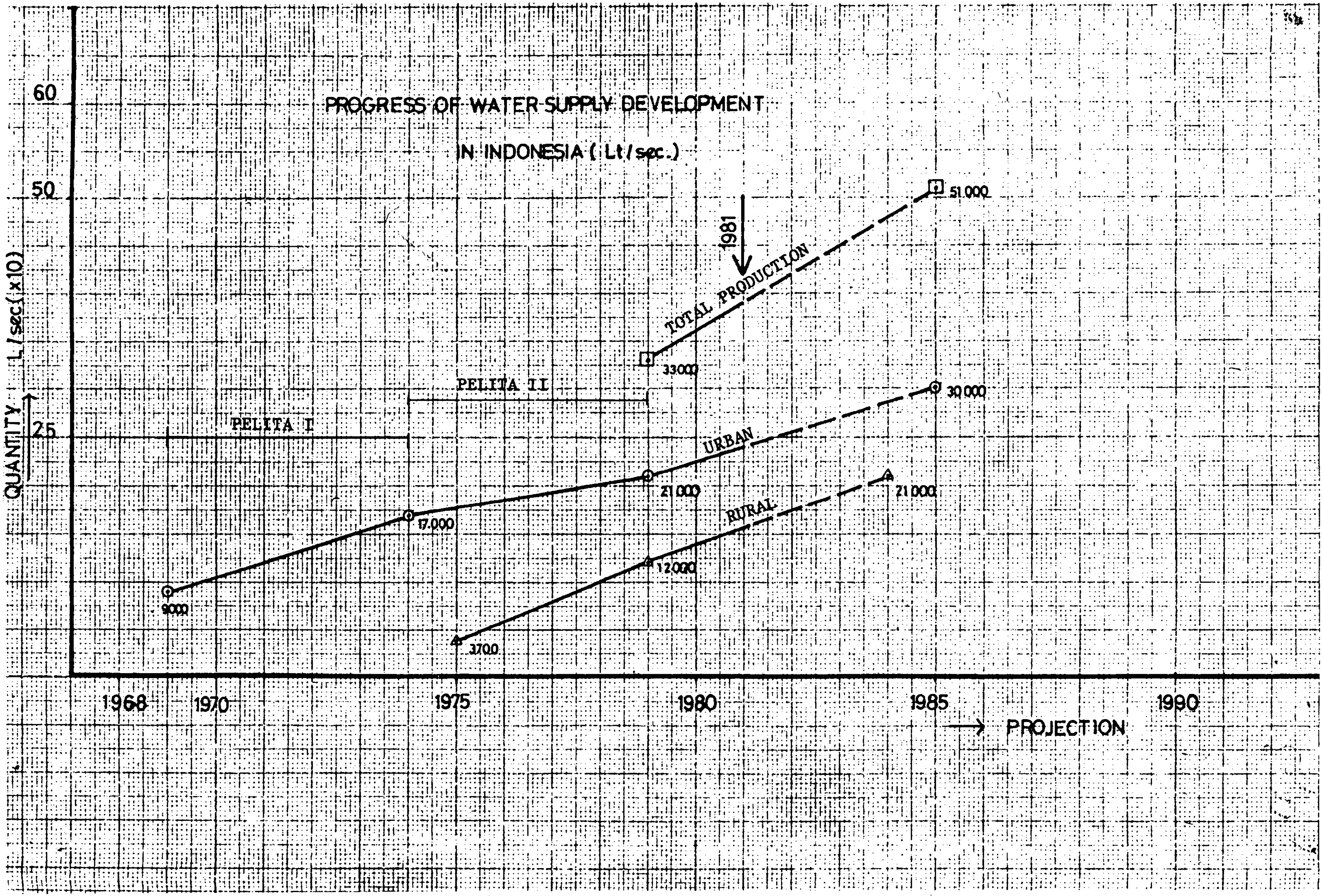
INDONESIA AVERAGE NUMBER OF INHABITANS
PER VILLAGE UNIT



1700-IKK (1981 - 1984)




THE TRENCH OF POPULATION INCREASE
IN INDONESIA (IN MILLION)
NUMBER OF POPULATION (x10⁶)
150
100
50
0
1930
1961
1971
1976
1981
1985
1991
GROWTH RATE 2,2 %
GROWTH RATE 1,2 %
TOTAL POPULATION
URBAN
GROWTH RATE 4%
GROWTH RATE 1,5%
RURAL
61
98
120
140
170
100
107
110
112
73,5
21
25
30
35
6,5
12,2
0,9
5,04
10
served by others (dug well, rain water etc.)
total population served
population served in urban
population served in rural area



PROGRESS OF WATER SUPPLY DEVELOPMENT
IN INDONESIA (Lt / sec.)
QUANTITY L/sec (x10)
60
50
25
1968
1970
1975
1980
1985
1990
PROJECTION
PELITA I
PELITA II
1981
TOTAL PRODUCTION
URBAN
RURAL
9000
17.000
21.000
30.000
33.000
51.000
3700
12.000
21.000

APPROPRIATE MATERIAL STANDARDS FOR DEVELOPING COUNTRIES

by ROMUALDAS G. VILDZIUS

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I. INTRODUCTION

A. Objectives of the Presentation

1. To determine and analyze the condition which usually prevail in developing countries during the establishment of water works systems (Technological, economic, sociological and geopolitical).

2. To define the limits (parameters) and basic principles (criteria) for the selection of specifications.

3. To cite some specific examples of applicabel specifications and their alternatives.

B. Definition of Systems

In developing countries water works may be divided into three basic classifications:

1. *The Rural Water System:* The Rural Water system is usually developed and subsidized under Rural Development Programs and reimbursed upon formation of a "Water District" from blanket rural development funding, derived from soft loans provided by international loan agencies i.e. World Bank, AID, ADB, WHO, etc. This system usually has communal outlets, and lends itself to supply with modular or "standard" equipment systems or packages.

2. *The Village System:* The Village System is usually undertaken and financed by the government or a private subdivision developer, under Government pre-requisites for minimum consumer service as well as fire protection and potability of water.

Most developing nations have initial subsidies for technical assistance and construction funding, not unlike the provisions for rural development except that "Pay back" is shorter term, derived from sale of the lots in the subdivision or by special assessments of the individual property owners. This system often has "restrictor" controlled house connections.

Basic loan agreements usually incorporate standards of design for water source development, treatment facilities, distribution, storage and control. Again, modular packages can be adopted but require greater sophistication.

3. *The City or Area System:* The City/Area systems are usually financed by "water district" bond issues or by long term, soft loans, by Government to Government Agreements, or by international development loans, with a counterpart by the developing nation which is the beneficiary of the loan. The City/Area system has a full compliment of storage reservoirs pumping stations, elevated tanks for pressure control and a complex distribution system controlled by numerous valves and meters.

C. Common Factors

While the sources of financing may differ for the above two types of systems[1], the design, installation and operating conditions are still likely to be relatively comparable in any one country.

Therefore, the same basic principles for the selection of material standards apply to both types of systems. The difference is only one of emphasis – and will be found mainly in the selection and sourcing of materials: In the sourcing for "Village Type" systems, a maximum of emphasis should be placed on locally manufactured materials, which are readily familiar to most operating and maintenance personnel. While the "City Type" systems will necessarily have to have more sophisticated equipment, and a larger proportion of imported materials.

This paper will address itself to the basic conditions (parameters) commonly prevailing in developing countries, and will try to determine the most useful principles (criteria) for the selection of material standards.

D. Design Criteria and Material Selection

Design criteria and material selection is usually initiated in the feasibility study which is prerequisite to every government and lending agency involved in waterworks development.

To establish a preliminary cost estimate, the study consultant must consider the entire spectrum of materials and equipment and select those best suited and most easily obtainable to the area of interest. In most instances, the concepts and materials proposed in the study are reflected in final design and construction of the project.

The consultant to a large extent is guided in both technical concepts and material selection by the standards established by the national governments and the lending agencies involved. In many instances where government to government loans are concerned, the loaning government enforces an economic policy of requiring most material components to originate from the nation granting the loan. (i.e. tied loans) or from a limited number of nations.

II. PRE-CONDITIONS FOR ESTABLISHING A WATER SYSTEM

In order to determine the appropriate standards, it is essential to understand the usual conditions which prevail in developing countries during the establishment of a water works system or a major expansion of an existing system:

A. *Technologically* there is an increasing amount of know-how in the manufacture of basic water works materials such as pipes, valves, pumps and meters; although in varying degrees of sophistication.

B. *Economically* there is usually a limited ability to pay for the acquisition and installation of a system outright[2]. Hence the need to obtain foreign, long term financing.

C. *Sociologically* there is a desire for the services of a waterworks system – but a resistance to pay for it. This is mainly because, prior to its installation, water – while inadequately supplied – was frequently either free of charge or minimally paid for by the consumer.

D. *Geopolitically,* developing countries by definition, have to rely on some foreign or international financing and supply. This procurement requires a selection of types of materials and equipment, which should be chosen for importation. Such criteria should be set regardless of the source of financing, particularly since the latter often causes the technological orientation of the design criteria and the specifications.

E. *Project Start Up – Concentration of Expertise.* In addition to the above mentioned general conditions, a specific set of circumstances usually holds true of projects financed by long term loans (normally the case in Water Works Projects): There is a high standards of know-how available for the design of specifications, manufacture of equipment and the initial installation and start-up of the systems – as part of the project financing package.

F. *Project Operation Problem: Maintenance.* The major problem arises in the long term maintenance of the system – particularly in the more rural and remote locations, where such know-how is not readily available. Yet, a system can only pay itself out (either directly or an an infrastructure catalyst to development), and a loan can only be self liquidating if there is a pay back. Either of the above objectives can only be achieved if the system oeprates well in the long run.

III. PRINCIPLES FOR SELECTION

Because of the above conditions, the following principles can be drawn for the selection of appropriate material standards for developing countries:

A. Select the products which are engineered to require a *minimum of maintenance* during its operating life and have a quality standard, which is adequate to insure a sufficiently long, effective life.

Simplicity of installation, while desirable, is less important because of the expertise available at most levels during the initial installation, i.e. among the owner, consultants, contractors and inspectors. The objective is to at least pay back long term loans, and preferably have a minimum of maintenance throughout the standard design life of 50 years. The long term loans usually have a pay back period of about 20 years. In analyzing the length of effective life, it is essential to evaluate a product for possible "weak links" i.e. materials with much shorter life than the main products – such as steel springs and rubber o'rings in brass corporation stops, which may only have one half or one third of the effective life of the brass valve itself.

1. *The First Choice – Local Materials*

The ideal choices are locally manufactured materials and equipment made from locally available raw materials, provided they meet the quality and design criteria of (a) adequate and uniform length of life and (b) minimum maintenance. This would give the greatest assurance that in the maintenance and repair both the correct raw materials and/or spare parts would be readily available, as well as the know-how for such maintenance (if need be from the local manufacturer).

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[2]Except in major oil producing countries.

2. *Second Choice – Imported Materials with Low Maintenance Needs*

The second best choice would be imported materials or equipment that would offer the needed long term operation and are designed for a minimum of maintenance.

However, whether an item is procured locally or from abroad there are critical "links" such as valve stems for gate valves and linings for gate and butterfly valves should be very carefully and precisely defined either in the form of metallurgical or chemical composition or long term performance tests or both.

B. Encourage Design of Equipment for Developing Countries

In developing countries, it is necessary to design for the more demanding conditions of

1. rough handling,
2. water with a higher percentage of unscreened particles,
3. fluctuating water pressures,
4. a greater propensity for theft or pilferage,
5. and a lower standard of field maintenance.

To do so, greater encouragement should be given to new designs by allowing or asking for alternate proposals with equivalent performance but better maintenance characteristics.

To do so, greater emphasis should be given to –

a. define the desired performance or test criteria, which the materials or equipment must meet – rather than specify design too precisely:
b. Require rigorous pre-qualification: (1) by clearly proven past performance (track record), and/or (2) by product & plant inspection with product testing and plant capacity rating.
c. Insist on internationally unassailable inspection and test organizations and procedures.
d. Allow leeway in design features – provided the equipment "Mates" or matches in terms of dimensions and joining methods with the rest of the system, and meets the performance criteria.
e. Encourage modular design and construction of equipment, which allows the easy replacement of such modules in remote district shops – with repair or overhaul in central regional or national shops. This approach often proves itself both more effective and economical.

IV. EXAMPLES OF DEVELOPING COUNTRY MATERIALS AND EQUIPMENT

Below are some examples of effective adaptation in product design to field conditions in developing countries – versus their alternatives.

A. *Pipes –*

Cement coated and lined vs. Coal Tar (Bitumen) coated and lined. Sand and cement is usually and readily available in developing countries. On the other hand, bitumen or coal tar is found only in countries with basic, integrated steel production capabilities.

Bitumen or coal tar, which is required in field jointing, is often pilfered and sold for use in patching up G.I. sheet roofing. Also, it can be easily misapplied in the field by excessive heating which results in brittleness or the inadequate cleaning of the joints, which could cause the bitumen to peel off.

Sand and cement, on the other hand, is readily available in most parts of the developing countries. Its application is well known to most construction workers, it requires no extreme cleaning or preparation of the pipe joint or damaged section. In case of pilferage it can readily be replaced from local sources.

B. *Pumps –*

Screw Pumps vs. Piston Pumps. The screw pumps have a minimum of parts for replacement and can cope with the large amount of unscreened particles in the water. The screw pump often has a higher initial cost, which is compensated by a longer performance life.

C. *Valves –*

1. Permanent seals vs. Packing glands

Recently developed permanent seals have a distinct advantage over packing glands, since they allow a minimum of maintenance for up to 10 years, as against the much more frequent attention required by packing glands.

2. Metal to metal valves vs. spring loaded O-ring seated valves, Corporation Stops are examples of differing length of life in a single item: O-rings and springs could have 1/2 to 1/3 of the design life of the brass body. Careful attention must be apid to insure that all components have the usually required design life of 50 years.

D. *Meters –*

Modular, Super Dry Single or Multi Jets vs. Positive Displacement Piston Meters. Typical examples of modern technology are the development of multi jets, and particularly the super dry single jet meters. The single jets allow the passing of larger unscreened particles. However, great care must be taken to specify that such single jets must meet the same specification for accuracy, magnetic shielding, etc. as multi jet or positive displacement meters. Simultaneously, the super dry modular construction of such meters lends itself to very easy replacement maintenance in the field or remote districts. The smaller body of modern single jets further reduces the risk of theft or pilferage due to its lower copper weight.

V. MAINTENANCE – NEED FOR SPECIAL ATTENTION BY OPERATORS AND FINANCIERS

To insure the continuous operation of water works systems and to guarantee the pay-back of loans, greater emphasis needs to be placed on the annual allocation of funds for the training of maintenance personnel. Such sums should not only be included in operating budgets of water works, but also as formal components of loan agreements as well. Maintenance is also an ideal area for aid programs (soft loan-type). The objective should be to achieve and continuously maintain a very high level of know-how Skills and Tolling (Equipment) in the Central (regional or national) repair shops for the repair and overhauling of water works equipment.

This would enable the adoption of systematic programs for either (a) preventive replacement maintenance or (b) breakdown maintenance (or a combination of both).

Such training must be continuous, since skilled maintenance and repair technicians are among the most likely to be hired away by the higher paying private sector and by overseas recruiters.

VI. OTHER CONSIDERATIONS OF DEVELOPING COUNTRIES

From the Developing Countries' viewpoint, the establishment of high standards in their operating systems should usefully be coupled with a conscious effort to encourage the development of high quality, financially strong local manufacturers, particularly those with a high content of local raw materials and/or with a strong export potential. Such selections are best made on a national level since they require not only technical but also macro-economic considerations.

VII. CONCLUSION

By virtue of the conditions prevailing in developing countries, and because of the requirements of financing institutions it is effective to specify criteria for material standards, which would result in the procurement of the following two types of materials:

A. Locally available basic materials (such as pipes, tanks, etc.) with a standard design life of 50 years. Local waterworks maintenance crews would be thoroughly familiar with such materials, and could, therefore, ***easily maintain and repair*** them with locally available parts or materials.

B. The more complex or sophisticated (local or foreign) equipment or materials should be engineered in such a manner, and constructed to such a level of quality, as to operate with a ***minimum of maintenance*** during the required design life. Simplicity of installation, while desirable, is less important because of the expertise available during the initial installation.

The solution would be to have the above incorporated in an international standard, such as ISO. If need be under a special section for developing countries. However, this will understandably take considerable time. In the meantime, therefore, the guidelines in this paper have been structured in such a manner that they could be superimposed as pre-requisites over any national or international standards, pending the establishment of formal standard for developing countries.

TREATMENT TECHNOLOGY IN GREATER TAIPEI AREA

by MING-TSU HUNG

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1. Introduction

Founded in 1908, the public water supply in Taipei has a service record of 73 years. The slow sand filtration plant established then was designed to produce a maximum of 15,000 CMD of water for serving population of 120,000. At the end of World War II the supply capacity was 50,000 CMD. The system has been rapidly expanded after the restoration of Taiwan to China, especially in the last two decades. The First Stage (1964) of regional development project increased the supply capacity by 200,000 CMD, the Second Stage (1971) added another 240,000 CMD, and the Third Stage (1971) brought the output capacity up to 1,300,000 CMD sufficient for supplying 3,200,000 persons in Taipei region.

2. Historical Review

2.1 *Historical Review*

The entire Taipei regional water supply system can be summarized in Table 1, with regard to their water sources, capacities, and major treatment facilities.

Water resources in the vicinity of Taipei which can be considered as sources for additional municipal water supply exist mainly as surface waters. Ground water is also available in the western portion of the City, however, due to over pumpage the yields are not sufficiently bountiful to permit economical development. The available surface water sources for the Taipei Regional Water Supply are the Hsintien Creek on the South. Selecting it as the source of supply would be eventually based on its relative merits of quantity of flow and quality of water.

The existing Kung-Kuan intake was the only potential intake site downstream of Chingtan, and the stream pollution made this site unsatisfactory for domestic water supply use. The Chingtan weir is the site of the Third Stage intake, water quality at this point is as good as the other intake sites and is suitable for water supply.

Table 1
EXISTING WATER SUPPLY SYSTEMS

Production System	Kind of Source	Max. Capacity ($x10^3$ CMD)	Major Treatment Facilities
1. Hsintienchi Plant	Hsintien Creek	600	C.RM. SM. S RF. Chl. P.
2. Chanchushan Plant	Hsintien Creek	540	C.RM. SM. S RF. Chl. P.
3. Yangmishan System	1. Yangminshan Springs	25	Chl. P.
	2. Shuanchi Stream	25	C.SM. S. SF. Chl. P.
	3. Shihlin	2	Chl.
4. Nanking & Neihu	1. Keelung Creek	10.3	C.RM. SM. S. RF Chl.
	2. Palienlishan Stream	6	C. RM SM. S. BF Chl.
5. Peitou System	1. Chuanyuan	12.5	C. BM. S. RF. Chl.
	2. Palaka etc.	29.4	SF. Chl.
6. 21 Deep wells	Ground Water	50	Chl. Cal.
Total capacity		1,300.2	

Remarks: BM-Baffled mixed; C-Chemical coagulation; Chl-Chlorination; Cal.-Calgou; SM-Slow mixing; RF-Rapid sand filtration; RM-Rapid mixing; S-Sedimentation; SF-Slow sand filtration; P-pH adjustment

2.2 *Water-quality Characteristics*

Water-quality characteristics often vary widely by location and season for any source of water. The sampling and analysis program of sufficient scope have been conducted to discern the variations in water quality that may affect treatment since water supply system established.

"Criteria of quality of drinking water in Taiwan" (refer to Table 2) are intended to serve as guidelines, although design engineers and plant operators should be aware that keeping the quality of drinking water within these guidelines makes it much more acceptable to consumer, thereby decreasing, complaints, and possibly later expensive modifcations.

From the pollution indicators the raw water of the Tahan Creek and Keeling Creek are seriously polluted, the raw water in Hsintien Creek at Chingtan is the least polluted.

The aquifer in the City of Taipei is generally located at 50 m below the ground surface having a thickness of 20 – 30 m., and the water yield is fairly abundant. In the North-western portion of the City, the quality of ground water is fairly good and suitable for drinking, however, in the North-eastern portion, the ground water is high in turbidity and iron content and can not be used for drinking purpose without treatment. There are still 21 wells in operation. After completion of the Fourth Stage Project, all these wells will not be operated except that 15 wells be maintained for emergency uses.

Test results of these water samples are listed in Tables 3-5.

Table 2

CRITERIA OF THE QUALITY OF DRINKING WATER IN TAIWAN

ITEM	Maximum Allowable Concentration, mg/1
Lead, Pb	0.1
Selenium, Se	0.05
Arsenic, As	0.1
Chromium, Cr^{+6}	0.05
Cyanide, CN^-	0.01
Cadmium, Cd	0.01
Silver, Ag	0.05
Mercury, Hg	None
Pesticides	None
Fluoride, F -	0.8
Nitrate nitrogen, NO_3^--N	10
Iron & Manganese	0.3
Copper, Cu	1.0
Zinc, Zn	5.0
Phenol	0.001
Alkylbenzene Sulfonates	0.5

Item	Maximum Allowable Limit
Color, Platinum units	5
Taste & odor	None
Turbidity, JTU	5
Coliform, MPN/100 ml	2.2
pH	7.0-8.5

Table 3

QUALITY OF RAW WATER OF CHINGTAN (Hsintien Creek 1)

Item	Nov.-Dec. 1971 Range	1973 Range	1980 Range (NTU)	Treated Water 1980 Range	Median
Turbidity, JTU	7-155	3.3-770	1.02-361	0.1-0.7	0.4
Alkalinity, mg/1	16-30	12.38	14-52	18-44	31
pH	6.7-7.2	6.9-7.3	6.8-7.5	6.4-6.9	6.6
Chloride, mg/1	6-12	3-13	4-9	5-11	8
Sulfate, mg/1	8-14	6-16	9-23	11-28	20
Fluoride, mg/1	0.05-0.12	Trace -0.06			
Ammonia Nitrogen, mg/1	Trace	Trace	0.01-0.02	0	0
Nitrite Nitrogen, mg/1	Trace-0.003	Trace -0.70	0-0.003	0	0
Nitrate Nitrogen, mg/1	0.1-0.3	0-0.23	0-10-0.56	0-0.51	0.17
Total Hardness, mg/1	24-48	12-44	28-60	30-58	44
Total Solids, mg/1	82-276	88-1, 212	34-90	41-90	66
Calcium, mg/1	6.4-12.8	4.8-12.8	8.0-17.6	8.8-16.8	12.8
Iron, mg/1	0.2-4.0	0.08-10.5	0.12-3.48	0-0.16	0.08
Magnesium, mg/1	1-5	0-0.20	2-6 (MF)	1.5-4.5 (MF)	3.0 (MF)
Coliform, MPN	1,500-11,000	75-11,000	0-11,000	0	0

Table 4

QUALITY OF RAW WATER OF KUNGKUAN INTAKE (Hsintien Creek 2)

Item	Jan.-Oct. 1957 Range	1961 Range	1970 Range	1976 Median
Turbidity, JTU	5-2,300	34-144	24-78.4	45.3
Alkalinity, mg/1	16-44	28-43	27-50	31.6
pH	6.9-7.3	6.9-7.2	7.3-9.3	7.4
Chloride, mg/1	3.4-9.8	6-13 .2	6.5-15.0	11.8
Sulfate, mg/1	3.1-20.2	8-30	15-28	31.4
Fluoride, mg/1				
Ammonia Nitrogen, mg/1	0.2-0.085	0.003-0.035	0.03-0.42	0.014
Nitrite Nitrogen, mg/1	0.002-0.015	0.001-0.014	0.0015-0.0105	0.023
Nitrate Nitrogen, mg/1	0.03-0.18	0.05-0.14	0.025-0.12	0.25
Total Hardness, mg/1	24-69	36-54	40:5-66.5	44
Total Solids, mg/1	68-312	60-210	104-425	84
Calcium, mg/1	6.4-14.4	8.8-13.0	7.8-17.0	10.6
Iron, mg/1	0.01-1.55	0.3-0.73	0.875-4.9	0.93
Coliform, MPN	240-24,000	5,640-14,743	20,000-130,000	114,000
Magnesium, mg/1	2.0-8.25	3.3-6.5	3.65-6.9	4.0

Table 5

QUALITY OF GROUND WATER AT TAIPEI & VICINITY (1980 Average)

Item	Tali School (Taipei S-W)	Chenkuo N. Rd. (Taipei NE)	14 Chang (Hsintien)	Futeh (Sanchung)
Temperature °C	21	24	20.5	23.8
Turbidity, NTU	0.23	0.64	0.5	0.8
Alkalinity, mg/1	75	125	55	80
pH	7.4	7.6	6.9	7.8
Chloride, mg/1	9	51	9	15.3
Sulfate, mg/1	28	69	21	25.7
Fluoride, mg/1	0.21	0.9	0.35	0.64
Ammonia Nitrogen, mg/1	0.06	0.12	0.13	0.17
Nitrite Nitrogen, mg/1	0.0008	0.002	0.001	0.0017
Nitrate Nitrogen, mg/1	0.11	0.015	1.55	0.007
Total Hardness, mg/1	84	163	60	57.3
Total dissolved Solids	130	333	120	162
Calcium, mg/1	22.4	44.4	14.4	13.6
Iron, mg/1	0.12	0.10	0.013	0.38
Magnesium, mg/1	7	13	6	5.8
Bacteria, Colony	24	2	190	6
Coliform, MPN	0	0	7	0

2.3 *Treatment Methods*

Some appropriate treatment methods have been used in Taipei water supply system since 1908. These methods are summarized and tabulated as follows:

Year	Plant Type	Treatment Briefing
1908	Slow sand filtration plant Q = 42,000 CMD (Max.) (Hsintienchi plant)	a. Sedimentation basins: Detention time 9hrs. Overflow rate 6 m/day b. Slow sand filters: Single media (Conventional sand) Filtration rate 3.05 m/day 5.16 m/day (max.)
1952	Rapid sand filtration Q = 20,000 CMD (Design) 32,000 CMD (Max.) (Hsintienchi plant)	a. Flocculation basin: Ave. velocity 0.29 m/sec. b. Sedimentation basins: Detention time 3.6 hours Overflow rate 246 $m^3/m^2/day$ c. Rapid sand filters: Single filter media Filtration rate 125 m/day (Design) 200 m/day (Max.)
1956	Slow sand filtration plant Q = 21,700 CMD (Max.) (Shuanchi Plant)	a. Sedimentation basins: Detention time 2.5 hours Overflow rate 35.5 cmd/m^2 b. Slow sand filters: Single filter media Filtration rate 4.75 m/day (Design) 5.16 m/day (Max.)
1962 -1964	Rapid sand filtration plant (1st Stage Development Project-Chanchushan plant) Q = 200,000 CMD (Design)	a. Flocculation basins: Ave. velocity 0.026 m/sec b. Sedimentation basins: Detention time 2 hrs. Overflow rate 46.4 $m^3/m^2/day$ c. Rapid sand filters: Dual filter media (Anthracite-sand) High-rate 261 $m^3/m^2/day$ Constant-rate and constant-water-level filtration)
1968- ditto-	Q = 240,000 CMD (Design) 260,000 CMD (Max.)	a. Sedimentation basins: Detention time 1.5 hrs. Overflow rate 60.6 $m^3/m^2/day$ b. Rapid sand filters: Application of variable declining-rate filter control method with existing equipment, filtration rates were successfully increased to superhigh-rate 340 $m^3/m^2/day$ to increase plant production
1969-1971	–ditto– (2nd. Stage Development Project-Chanchushan Plant) Q = 240,000 CMD (Design)	–ditto–
1974	Rapid sand filtration plant (Upgrading Hsintienchi plant) Q = 48,000 CMD (Max.) 40,000 CMD (Design)	a. Flocculation basins: Detention time 14.4 min. 12.0 min. (Max.) b. Tube settlers: Detention time 123 min 123 min 96 min (Max.) Tube modules area 415.8 m^2 c. Rapid sand filters: Mixed-filter media Filtration rate 380-420 m/day The existing treatment installation were modernized with settling tubes and high-rate mixed-media filter and their output doubled.
1973- 1977	Rapid sand filtration plant (3rd. Stage Development) Project-Hsintienchi Plant) Q = 480,000 CMD (Design) 520,000 CMD (Max.)	a. Flash mixers (Axial flow impell): Detention time 60 sec. b. Flocculation basins: Detention time 34.67 min. c. High-rate sedimentation basins (Rectangular with sloping plates and mechanical sludge collector) Detention time 100 min Weir overflow rate 254 $m^3/m^2/day$ d. Rapid sand filters Dual filter media (constant-rate control) Filtration rate 300 m/day
1980- 1981	Rapid sand filtration plant (4th Stage Development Project 1st. phase, Chanchushan plant) Q = 200,000 CMD (Design) = 240,000 CMD (Max.)	a. Rapid mixing: Detention time 43.8 sec. (Max.) b. Flocculation basins: Detention time 21.4 min (Max.) c. Sedimentation basins; Detention time 1.4 hrs. (Max.) Overflow rate 218 m^3/day m (Max.) d. Greenleaf fitlers: Dual filter media (50 cm of anthracite ES 0.5 mm) Filtration rate 255 255 m/day (Design)

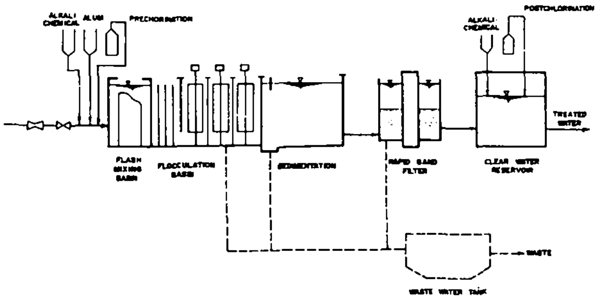

FIG. 1 CHANCHUSHAN WATER TREATMENT PLANT PROCESS FLOW DIAGRAM

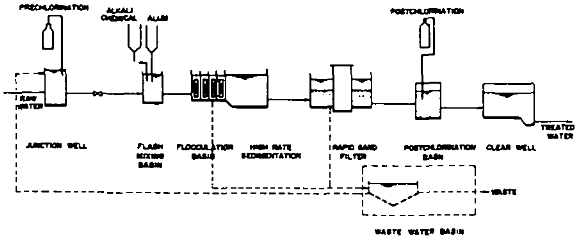

FIG. 2 HSINTIENCHI WATER TREATMENT PLANT PROCESS FLOW DIAGRAM

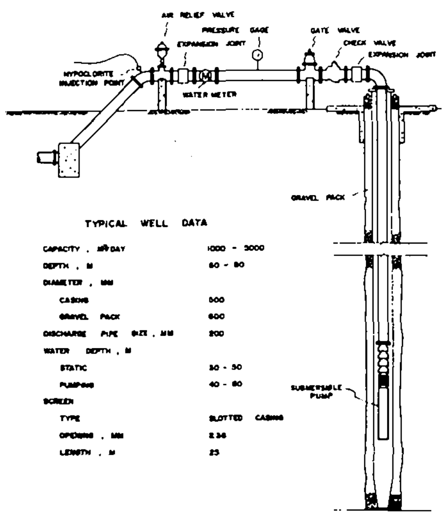

FIG. 3 TYPICAL DEEP WELL PUMPING STATION

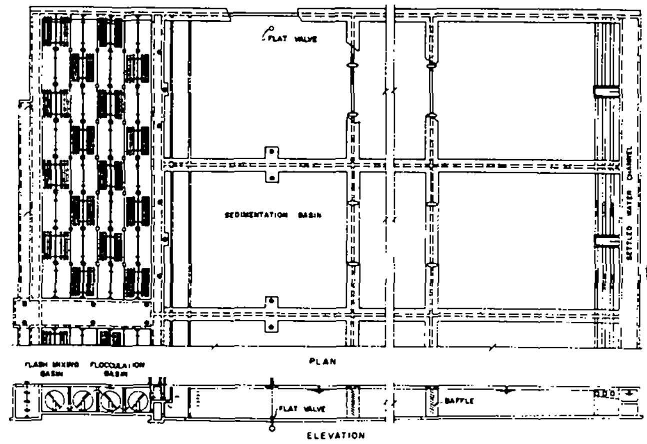

FIG 4 CONVENTIONAL SINGLE DECK SEDIMENTATION BASIN

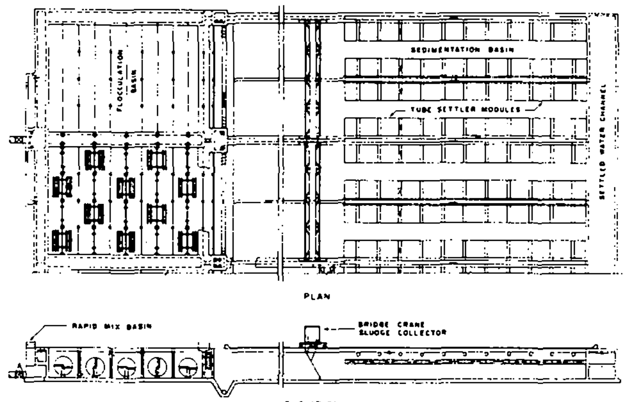

FIG 5 HIGH RATE SEDIMENTATION WITH TUBE SETTLERS

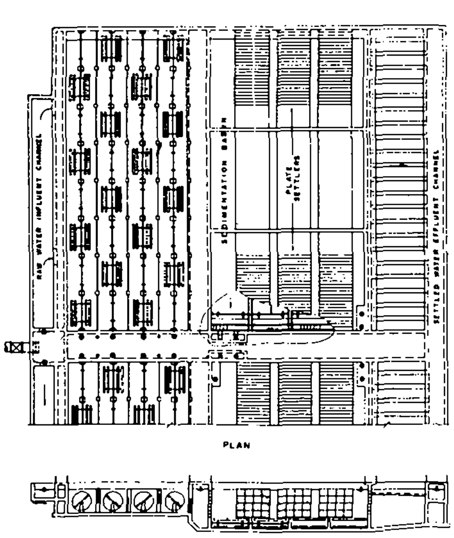

FIG 6 HIGH RATE SEDIMENTATION BASIN WITH SLOPING PLATES

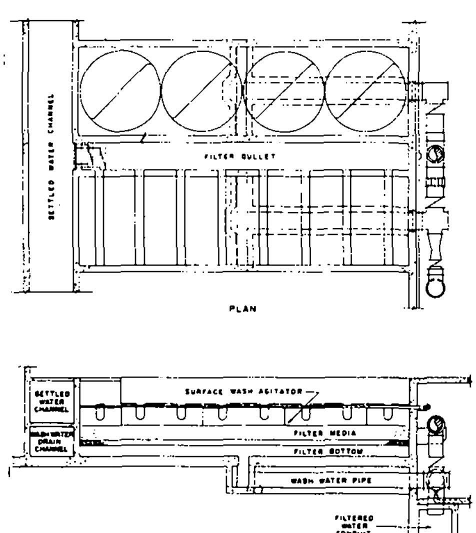

FIG 7 LARGE CONVENTIONAL FILTER

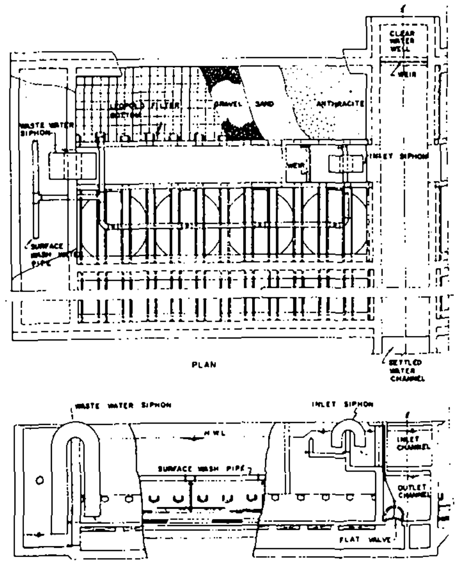

FIG 8 GREENLEAF FILTER

	306 m/day (Max.)
	The low orifice loss system for washing filters with filter from other filters.
1980- 1981 Pilot plant testing (4th. Stage Development Project 2nd phase-Chihtan plant) Q = 500,000 CMD (Design) = 550,000 CMD (Max.) x 5 units	Proposed treatment processes: 1. Tube-settler with greenleaf filter 2. Pulsator with aquazur V filter

Regardless of raw water quality, however, two types of treatment are commonly used;

1. disinfection (all drinking water, regardless of quality, should be disinfected by chlorination for our treatment practice).
2. filtration for all surface sources.

The early slow sand filter, dating from 1908, was operated of rate of 3.05 m/day using about 1 m of ungraded sand media to filter raw surface water in runs that lasted for as long as 3-4 months. The filter was calened by draining the filter to below the sand surface and scraping off the dirty skin formed at the surface of the sand.

With rapid population growths and large filters required led to criteria for the design of new rapid sand filters that operate at high rates. It was necessary chemically to pretreat water using alum or iron coagulants followed by flocculation and sedimentation of the water to reduce the solids load going to the filter. The filters were operated at rates of 125 m/day, with filter runs normally between 36-60 hr. under a pressure differential of 2.4-3.0 m of water. The higher rate forced the solids to penetrate deeper into the sand media and required the new backwash methods.

Floc preparation before sedimentation should consist of instant blending, rapid mixing, and staged floc aggregation, and it has as much significance as any other feature of the plant. The new high-rate settlers such as inclined plates or tube modules were used.

In the rate 1960s and 1970s, filtration rates were increased to 261-340 m/day to increase plant production with existing equipment. Thus the research led to development of dual- and mixed-media filters (referring Fig. 1-8)

2.4 *Expansion Project*

The fourth stage development

1. Target year of the project 1991
2. Estimated total population 4,100,000
   Population served 3,925,000
3. Popularity rate 96% in average
4. Water demand 2,180,000 CMD in average day.
   2,660,000 CMD in maximum day.

Outline of projects

A. Water supply project

Construction Period: 1981-1991, Cost NT$11.5 x 10^9

1. To construct Chihtan intake and raw water transmission line with capacity 2,700,000 CMD.
2. Three treatment plants total capacity 1,650,000 CMD (Each plant unit with capacity 500,000 CMD, the ultimate capacity of 5 plant units would be 2,500,000 CMD, and 2,750,000 CMD for 10% overloading in 2011)
3. Clear water transmission line 27 Km
4. Distribution mains 105 Km
5. 11 distribution reservoirs, total capacity 214,000 CMD. 14 boosting stations, rated capacity 1,960,000 CMD.

B. Water source project

Construction period: 1979-1986, Cost: NT$13.15 15 x 10^9

Reservoir:

1. Concrete arch dam
2. Catchment area: 303 Km^2
3. High water elev. 170 m
4. Gross initial storage: 406 x 10^6 m^3
5. Effective storage: 351 x 10^6 m^3

Dam: Dam height 120 m, Total crest length 500 m

Power Plant:

1. Installed capacity: 70,000 Kw
2. Average annual generation, 400 x 10^6 Kw

The Fourth Stage Development Project is now proceeding on the third step, and Sinotech Engineering Consultants, Inc., Taipei in joint venture with another firm is assigned to work on the engineering services since 1971 (The 2nd. Stage Development Project). The 1st step involves preliminary engineering and includes a feasibility study. The 2nd. and concurrent step includes a pilot plant testing to optimize the design process, then forwarding preparation of the detailed engineering drawings and specifications, while the 3rd. step covers construction and test run.

Pilot testing of conventional sedimentation with dual-media high-rate filter, high-rate tube settler with greenleaf filter was conducted at the same location prior to development of pulsator with aquazur V filter testing program. Those units yielded acceptable results in reducing turbidity levels and suspended solids removal; however, the pulsator, which was operated with lower raw water turbidities, was more successful. Although raw water characteristics varied somewhat due to the different times of year under which the another experimental study of direct-filtration was also conducted by the Taiwan University at the same time, some relevant comparisons were made (referring Fig. 9-12).

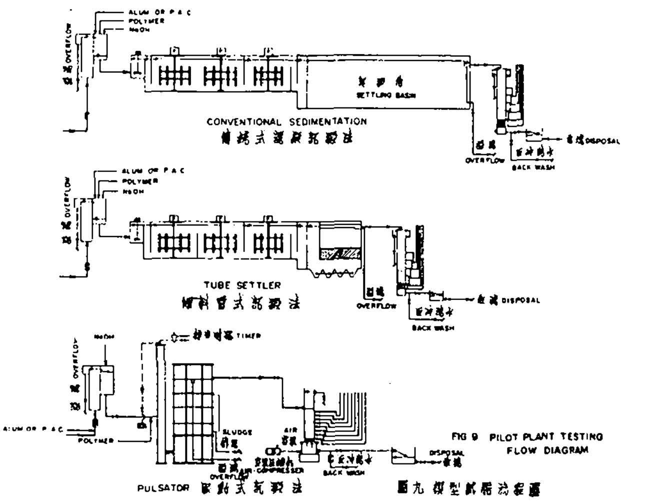

FIG 9 PILOT PLANT TESTING FLOW DIAGRAM
圖九 模型試驗流程圖

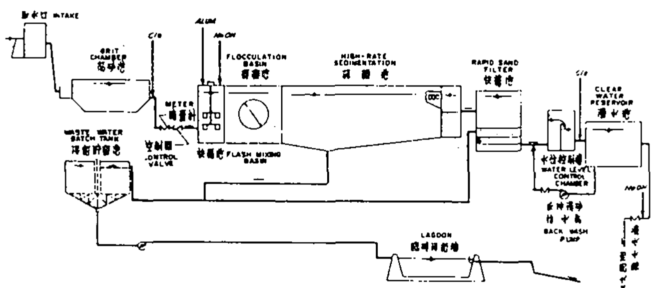

FIG 10 CHIHTAN WATER TREATMENT PLANT PROCESS FLOW DIAGRAM
圖十 直潭淨水廠流程圖
(…)

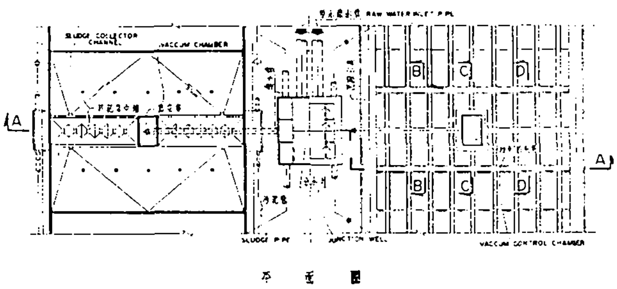

FIG 11 PULSATOR
圖十一 脈動式沉澱池(1/2)

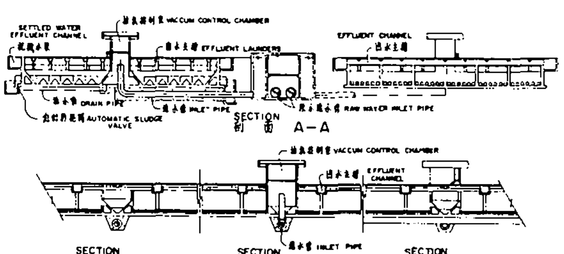

FIG 12 PULSATOR
圖十二 脈動式沉澱池(2/2)

3. Design Considerations

3.1 *Source Selection*

For selection of water source, the overall planning conception should be taken into careful consideration with respect to the water quantity and quality, and the possible need for coordination of the stage schemes for providing the source of the water supply.

Intake and treatment plant site selection and transmission system design can not be made independently. Each influences the cost and design of the other. A proper analysis must compare complete system alternatives.

New Chihtan treatment plant site of the Fourth Stage Development Project is to be selected downstream of Chihtan dam and reservoir on peninsula formed by Hsintien Creek. From the five proposed treatment plant sites, the Chihtan site which has the lowest present worth of site development costs unfortunately ranks fourth in 61 families displaced and third in initial capital cost. The advantages of the site are the largest available area for the long range development and that it will result in savings in power costs because of its high elevation and will have the reliability of a gravity-flow system. It will also be subject to flooding; however flood model testing was conducted prior to the construction of properly designed flood protection works which have been included in the cost analysis, flooding should not be a problem.

As a result of the comparison and study of all available streamflow records, it is obviously beneficial to take water for the long range development of the Taipei Regional Water Supply Project from Hsintien Creek. The Hsintien Creek is a better choice in terms of economy, engineering, quality of water, and the possible requirement for recreational resources.

3.2 *Treatment Process Selection*

Laboratory investigations or pilot plant testing should be conducted for most water-treatment-plant processes. Reports should be prepared for evaluation of the alternatives of each selected unit process, including preliminary site and architectural layouts, cost estimates of construction and operation, design criteria and schematics.

The basic treatment process were considered for each treatment unit, and the process includes the following:

1. Chemical addition
2. Pretreatment
   a. Chemical mixing
   b. Coagulation and flocculation
   c. Sedimentation
3. Filtration
4. Disinfection
5. Chemical stabilization
6. Wastewater recovery and sludge disposal
7. Instrumentation

Chemical addition. Alum, lime and chlorine have been the three chemicals traditionally used in most water-treatment plants, and are available in Taiwan. However, many choices are now available and polymeric and iron coagulants, potassium permanganate, granular and powdered activate carbon for color, taste and odor removal; soda ash or caustic soda for pH adjustment; sodium silicate or Zinc-phosphates for corrosion control; sodium and calcium hypochlorite and ozone as disinfectants. There is one common denominator in consideration of chemical storage and feed system; wherever possible, a liquid chemical storage, handling, and feeding system is usually the most economical in initial and operation costs. Bulk handling of dry chemicals usually will be more economical than bag handling and batch preparation. Chemical storage facilities should be planned with sufficient capacity for at least a month of storage, usually in duplicate facilities. Production and transportation interruptions can be expected, and the treatment facility must be operable during these periods. Chemical feed points, metering, and rate-adjustment controls should be convenient to the operational staff. Centralization of nearly all chemical feeding facilities in close proximity to the main control room and laboratory is desirable.

Pretreatment. It has been found in each of the aforementioned treatment facilities that introduction of alum and some polyelectrolytes into the inlet pipeline or into a baffled mixing chamber is most effective. It is necessary to introduce the coagulant chemicals into a zone of high turbulence, such as ahead of a Venturi flow meter or weir, to provide rapid and complete dispersion before aggregation of floc occurs.

Flocculation is also a process with many alternatives that may be selected. In water treatment, the combination of flocculation together with sedimentation often must be considered as a combined process because the style and shape of tank units are interdependent. Sludge recirculation may be an important component in reducing chemical requirements as well as providing floc nuclei for growth of the precipitates.

Most modern sedimentation basins utilize mechanical sludge raking and frequent sludge withdrawal, primarily for reasons of operational economy. It is very important to consider the probable results of short circuiting whether thermal, wind, or velocity distribution induced. Tube settler are in use of Hsintienchi plant in rectangular basins for a plant expansion and inclined-plate settlers are also to be used at same plant in rectangular basins for a new installation. The economic comparisons of alternative types of flocculation and sedimentation facilities for these two treatment plants respectively are inexpensive in both operational and initial cost.

Filtration. Three alternative filter designs were considered for the 4th. Stage Plan. Only one of the filters is proprietary designs with prefabricated component and equipment furnished by the manufacturer. The cost of alternative filtration processes are compared in Table 6-8. The quality of the filtered water produced differs very little among the three types of filters. Filtered water quality depends more on filter rate, filter media and efficiency of pretreatment than the type of filter. The amount of water used for backwashing is about equal for all three filters.

All these filters are considered equal in performance for final design we would recommend selection of the least alternative at the time based on firm quotations on the aquazur V filter components since it is patented design.

Disinfection. Chlorination is considered the most effective means of disinfection for the 4th. stage project. Both prechlorination and post-chlorination would be required. Chlorine would be added in the raw water conduit at the head of the plant or in the flash mixing and in the filtered water piping to the clear well.

Table 6

COMPARISON OF PRETREATMENT PROCESSES

Pretreatment Process	Advantage	Disadvantage
Conventional upflow sedimentation	1. Easy operation and	1. Large area required
Pretreatment Process	**Advantage**	**Disadvantage**
Conventional upflow sedimentation	1. Easy operation and maintenance 2. Adapatable to raw water change 3. Capacity can be increased by use of tube settlers	1. Large area required 2. Manual cleaning unsuitable with sludge treatment process. 3. Possible short circuiting due to wind and density flow
High-rate sedimentation with tube-settler	1. Small area required 2. Adaptable to raw water change 3. High-efficiency due to laminar flow and min. effect of wind and density flow.	1. Mechanical sludge collector required 2. Difficult to maintain the tubes and sludge collectors 3. Prechlorination necessary to prevent algae growth
Pulsator	1. Small area required 2. High-efficiency of suspended solids removal 3. Low power consumption	1. Difficult to maintain 2. Efficiency poor with raw water change 3. Noise problem

Table 7

ECONOMIC COMPARISON OF PRETREATMENT PROCESS

	Conventional Sedimentation	Tube-settler	Pulsator
Total capital cost	341.9	227.6	215.0
Total annual maintenance cost	3.2	22.6	2.6
Annual power cost	1.3	0.8	0.7

1. as of Mar. 1981.
2. units in NT$ x 10^6
3. be base on the plant capacity 500,000 CMD.

Table 8

ECONOMIC COMPARISON OF RAPID FILTERS

	Conventional	Greenleaf	Aquazur V.
Total capital cost	179.1	148.4	150.8
Total annual maintenance cost	1.96	1.25	1.60
Annual power cost	0.68	0.19	0.39
Backwash water	1.36	2.04	0.97

Chemical stabilization. Hsintien Creek water at Chihtan is corrosive and will require pH adjustment for corrosion control and chemical stabilization. pH can be raised with soda ash, lime or caustic soda. Laboratory testing indicated the following quantities would be required of these three chemicals in order to stabilize a cubic meter of treated water from Hsintien Creek.

Chemicals	Quantity mg/1	Cost, NT$/ 10^3m^3
Lime (CaO)	6	15
Soda ash (Na_2CO_3)	23	150
Caustic soda (Na OH, 45% Sol.)	13	54

Lime is the least costly of the chemicals investigated. Unfortunately, locally produced lime has a very high percentage of impurities which make it difficult to feed and unsuitable for addition to the filtered water. Although caustic soda is more expensive than lime, the feeding system and storage facilities required for caustic soda are less expensive than those for lime. Caustic soda is also suitable for increasing the alkalinity of the raw water when insufficient alkalinity is present for coagulation with alum.

Wastewater recovery and sludge disposal At the existing Chanchushan and Hsintienchi plant, sludge removal from the settling basins and filter backwash water are discharged directly to Hsintien Creek. The simplest and most economical way to handle filter backwash water would be with a batch tank. The purpose of this tank would be equalize the flow of treatment plant wastes to the sludge lagoons, and thus, permit sizing all downstream piping for equalized flow rather than the peak filter backwash flow. The batch tank capacity would be sufficient for the maximum volume of water that might be wasted when a filter is cleaned. Waste disposal for the initial construction would consist of lagooning. Lagoons would be semipermanent and constructed downstream of Chingtan weir within the limits of the riverbed. The capacity of lagoons would be sufficient for one year's storage of sludge. The solids would settle in the lagoon and the supernatant would overflow to the Hsintien Creek from the top of the lagoons. In the future, some form of sludge treatment such as solids seperation and thickener is to be provided.

Instrumentation. The automatic water-quality sensors and controllers are to be installed. Nearly all of the sensors are electronic solid state devices of high accuracy and relatively low maintenance as compared to those used only ten years ago. Automatic data logging and trend recording of selected intervals, on alarm conditions, and upon demand by the operator, and minicomputers for calculating and posting such data as flows and water-qualities characteristics trends are also to be installed in the Chihtan treatment plant.

IV. Summary

The primary objective of the 4th. stage water treatment plant is to produce water that will be both safe and appealing to the consumer, under all conditions of raw water quality. In addition the plant should be designed and staged to minimize capital and annual costs without sacrificing dependability and easiness of operation and maintenance. In this paper, referring to the criticisms of the treatment performance the water treatment requirements are established, alternative processes are compared and the design criteria for the first increment construction are set up. These are summarized as follows:

1. From the point of view of cost analysis, the individual project costs much higher than a regional project.
2. Evaluating a potential water source is a matter of determining the amount of water and the quality of water available both on a long-term basis and on a short-term basis.
3. Applicable water quality standards and their meaning shall be carefully studied.
4. In selecting the site for the water treatment plant, consideration shall be given to factors such as: the distance between the plant and intake and the plant to its service area; and ground elevation of plant site. The plant shall be located at the site where the construction cost of the plant is low, operation and maintenance of the plant are safe and the physical environment of the plant is comparatively good. It should be noted that sanitary surroundings of the plant will minimize the chance of in-plant contamination and assure the good quality of water. For the purpose of minimizing the distance of raw water transmission, water treatment plants are generally located near a stream. In such cases the possibility of inundation in time of flood should be carefully considered.
5. The conduct of laboratory investigation followed by pilot studies if possible should be engaged in some detail, including comments on pilot flocculation, sedimentation and filtration.

This will enable the selection of the water treatment processes that are most effective and economic and that have favorable environmental and energy considerations.

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PRODUCT IMPROVEMENT IN PIPELINES FOR WATER SUPPLY SYSTEMS

by JOHN L. O'BRIEN Australia

Foreword

Ours, by present day standards, is a somewhat peculiar operation in that, unlike most professional consultants, our reward is measured for the most part only by our success – mind you we have our disappointments – but fortunately we can with a good deal of pride and satisfaction look back on many achievements in this field, a fact of which we are quite naturally justly proud.

I feel however that in many respects our continuing success is very largely due to the generous measure of co-operation that we have enjoyed over many years from our associations with Australian water and sewerage authorities, and indeed it would be remiss of me not to acknowledge this fact. There can be little doubt that were it not for this long, very interesting, and most rewarding association, especially with the Sydney Water Board, that I would not be privileged to address you here today, nor would many other experiences which I have enjoyed in my own country and in other parts of the world have been possible.

As most of you know, those products with which we are concerned, for the most part are used by, or the use of them, is largely determined by public utilities and without approval of the authority concerned demand would be extremely limited.

When the Chairman wrote to me suggesting in very complimentary terms that I may take part in this very important conference, I was flattered to observe, even in my declining years, that I am still recognized as an "expert" in the field of pipes for water supply and sewerage. I suppose this is due to my having made almost a life time study of most of those products and materials which cannot be done without in the reticulation of water and sewerage.

Actually I often wonder in this day and age, what qualifications are required for one to finally become an expert in their particular field of endeavour. If one is to accept the definition of an "expert" from the Oxford Dictionary, I guess I would qualify, for it simply describes *expert as trained by practice –skillful.* there would be little doubt that my training has been constantly supported by practice, as to the second part of the definition, who's to say! Nevertheless, it is fitting that I should share some of my experiences with you and possibly, if time permits, tell you a little about the more recent developments in which we are presently engaged.

United Nations World Water Decade

It is fitting too, that this conference and exhibition should take place during the early part of the United Nations World Water Decade which has launched in November last.

The opportunity for all nations to benefit from improvements in systems already functioning in developed countries should not be underestimated.

It is to be hoped that this conference, in providing the vehicle for an exchange of knowledge, will also go a long way towards providing the right approach for the fulfilment of those objectives which have prompted such an ambitious project.

At the outset, to realize that developed countries did not have the same opportunities when they were facing much the same task, is surely an incentive for us all to apply the knowledge we gain to the best possible advantage in the long term of those less fortunate than ourselves.

How often is it said *that money will not buy good health* there is no doubt though, that more health benefits can be gained from money spent on a water supply system than in any other way – this in effect is what World Water Decade is all about – that it is reported to require an expenditure of ten million pounds sterling a day, every day for ten years, to achieve the objective of the United Nations Assembly is not nearly so important as to know, that whatever money is raised will be spent wisely and that we may, as a result of our contributions at this conference, do something in a practical and physical sense to lessen the waste that sometimes does occur through the adoption of inappropriate technology.

Water Supply Development in the Asia Pacific Region

All of the problems that are envisaged for the United Nations do not necessarily apply in this area and indeed it would seem you are already well advanced as a result of the planning of experienced engineering consultants to take advantage of any or all of the improvements that I may be able to outline.

It is aptly said – *the history of pipe is the history of civilization – upon no other single product have the great cities of the world depended in such large measure for their health and comfort.*

It is on this theme that I would like to begin my talk to you about product improvement in pipelines for water supply. The knowledge that one is contributing (through his efforts) to the well being of his fellow man, is in itself not only a tremendous incentive, but also a great source of personal satisfaction and I thank you for the opportunity.

I need to take you back almost two complete decades to early 1962 in order to illustrate the single and most significant change in pipeline construction. A change which transformed entirely procedures, that is the physical act of laying a pipeline.

Prior to this date, pipelines were generally lead jointed, certainly all fittings in a pipeline were – in some states of Australia the roll in rubber ring had already been adopted for the jointing of pipes, in one other state the feeling towards alternative methods of jointing to lead is best, illustrated by the comments of one principal engineer who's contention it was *that so much time and money had been spent in educating his people in the art of lead jointing that he had no intention of authorising a change.*

In some respects I had to admire this man's determination, at least he had made a firm decision.

I had reason later to doubt the wisdom of this decision as the time duly arrived when pipe with the original socket for lead jointing was unprocurable. Although it was pointed out that either one in the size in question could be used for lead jointing, the alternative was totally unacceptable.

This is mentioned merely to illustrate the inflexibility with which manufacturers are sometimes confronted. Change is never easy with an established and proven material whereas more often than not new and unproven materials with no history to support performance seem to gain a measure of acceptance not previously accorded to an established product.

The attitude described does tend to place an effective restraint on progress and even on the improvement of products already known and accepted for the performance of the material from which they are made.

Product change, or improvement for a pipeline, is not, however, something that happens, as it does with a motor car or say a refrigerator – a pipeline in the sense we are discussing is something which, with a minimum of maintenance, should last much longer than one man's lifespan.

When the task of changing totally the design of cast iron fittings was embraked upon to incorporate rubber ring joints rather than lead, much the same kind of resistance was experienced. The greatest problem then, however, was not one of convincing those in authority of the merits attached to the availability of fittings which would have the same joint as the pipe, but that with rubber joints, fittings could be much shorter and as a result less costly.

It is difficult for one to realise now that the saving in cost was not in itself sufficient incentive for many engineers to accept readily the change. Obviously a great many were totally unprepared for such a radical change and it was some time before the shorter lengths were acceptable to every authority.

Strangely enough it was found in the course of investigations that much the same problem was being experienced in the United States of America and it does not require a great deal of imagination to realise that with 48 mainland states to contend with, complete agreement was not easy.

Although the advantages of the secured rubber joint had been fully realised by this time and proven beyond doubt in pipe, little had been done, even in the United States to influence the use of fittings with the same form of joint despite the advantages which must have been obvious. In actual fact bolted gland fittings with all the inherent problems of corrosion were preferred.

The achievement is of course history, but it is important that you should know that Australian technology produced first, in its entirely, the present range of rubber jointed fittings which are now universally accepted as best for pipeline construction.

The extent of development which took place then is about to be surpassed by the same people, with whom I was proud to be associated until the early 70's, moving into the production of ductile iron fittings now, to supplement the availability of ductile iron pipe manufactured in Australia.

This foundry and engineering works, one of the largest and best equipped of its kind in the southern hemisphere, has quite recently carried out a series of unprecedented tests for the purpose of establishing, in conjunction with the Sydney Water Board, the ultimate strength of iron fittings. These tests to destruction are designed to prove conclusively the safe working pressures to which iron fittings may be subjected, especially those in which doubt is sometimes expressed owing to a lack of positive proof or of sufficient data to support theoretical calculations.

The value of this work is inestimable.

It should however, be noted, that the standard required to produce this type of fitting and the tolerances that need to be maintained are not within the scope of every foundry.

It may seem that a lot of emphasis is being placed on the jointing of pipes and fittings in a pipeline but you can well imagine now, the tremendous benefit that will accrue for developing nations, who are able to take advantage of ductile iron pipe and the rationalisation of fittings which is very largely the result of a technological change which must be surely regarded as one of the major developments in our time.

Standardisation — the Effect that it can have on Developing Nations

Some idea of the value of rationalisation in standards can be gauged by the claim that in the Australian Standard for cast iron fittings for water supply adopted in 1965, to satisfy the requirements of each authority in our several states, combinations of fittings approaching 30,000 in number. were provided for and could be ordered and made.

Today, to the credit of everyone concerned and especially the Standards Association of Australia, that number has been effectively rationalised to the satisfaction of all parties and reduced to a total of well under 1,000.

The Australian Standard for cast iron fittings for water supply which hopefully will shortly be published as a revision of Australian Standard No. 1488 may well be regarded then as the best and most comprehensive document of its kind.

Apart from establishing a basis for quality control, the purpose of such a standard is to ensure interchangeability, a vital ingredient in pipeline construction.

The rationalisation in itself does not necessarily mean that design is restricted. Standard fittings will (in the vast majority of cases) satisfy the design requirements of a pipeline. What it does mean is that delays in construction can be avoided as regardless of intent, specials not only increase costs but invariably create unforseen problems to manufacture.

The Role of Australian Industry in the Development of improved ancillary pipeline products, valves, etc.

Automation is very much a reality in water Pollution Control Plants and it is doubtful if, up until recently, the real value of the knife gate valve has been fully realised.

The entirely new concept of a knife gate valve which is provided in the Australian made 'OBE' valve makes it an ideal choice for quite a number of applications not previously considered; but it's main application would be in sewage treatment plants, pumping stations and in those tank situations where in many cases penstocks were previously used.

These valves have several notable advantages over other knife gate valves — they are dropped tight in both directions of flow, they can be supplied with rising spindles or, with very little height loss, non-rising spindles. The latter can be totally enclosed providing complete protection of all working parts and ideally suited to wet wall conditions or total immersion. The stainless steel gate is totally enclosed within the body when the valve is fully open. Pneumatic and electric actuators are mounted directly onto the valve body thereby avoiding any external support frames. Proximity limit switches are fitted directly into the actuators or, in the case of wheel operated valves, within the bridge.

Spindle extensions are unique as a result of the body and bonnet design, providing total protection for the threaded section.

Air valves are now fitted with nylon aluminium balls in lieu of the rubber coated wooden balls which have proven troublesome in many areas. Production of these balls which are also suitable for use in hydrants (ball type), has been the subject of a good deal of research requiring high standards of quality in the casting, machining and coating processes. Balls finally produced have already been installed for an extended period in valves which previously have proven troublesome and reports indicate that performance now is satisfactory.

Adjustable spindle support brackets in cast grey or ductile iron are definitely preferred by authorities — the cast bracket in which the spindle support is simply adjusted is supplied complete with stainless steel fixing bolts. Less costly than a fabricated steel bracket the cast bracket also is unlikely ever to be affected by corrosion.

Floor Drain Valves are now made with a ductile iron bridge to which are fitted bronze replaceble guides. Where previously the life of such a valve may have been suspect, its life now with proper maintenance is unlimited. The ductile iron bridge height in each size is such as to provide unrestricted flow with the valve fully raised.

Ductile iron fittings which were mentioned earlier have been produced in Australia and it would seem that demand will in due course determine preferences — cast iron is of course quite satisfactory for water supply but the knowledge that shorter and lighter fittings in ductile iron are available is likely to influence the selection. This and the knowledge that higher pressures can be accommodated with ductile iron will unquestionably place a great deal of emphasis on the new design. It is anticipated that Australian standards for ductile iron fittings will follow closely the most recent British standards, however, the research tests previously referred to are bound to play a big part in the design of some fittings. To the best of my knowledge, the extent and depth of information gained from these tests has not previously been available. The fact that designs will now be examined in relation to results produced by an Australian industry reflects a good deal of credit upon those concerned especially having previously initiated the use of this type of fitting.

Mention should be made of our involvement currently in the investigation of house service main cocks and the method of attachment to the water main.

Corrosion — preventative measures

The use of polyethylene tube seems to have been adopted now almost throughout the world as the most effective form of protection against the corrosion of cast iron pipes.

q A paper delivered in 1971 at the Auditorium of the Sydney Water Board, sets out more clearly than I can hope to convey now, the best means of protecting pipes in highly corrosive soils.

It is, however, interesting to note that in all of the water supply situations examined, there has not been one instance where cast iron fittings have been adversely affected by corrosion.

The progress of sanitation throughout the world has been closely associated with the availability of water; and the larger the quantity and the better the quality of the water, the more radical and extensive has been the advance of public health.

World Health Organisation
Monograph Series No. 42, 1959.

CURRENT TECHNOLOGY FOR DESIGN AND INSTALLATION OF STEEL WATER PIPE IN JAPAN

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1. Introduction

Steel pipe has been used for many years in Japan for water lines supplying or transmitting potable, industrial, or agricultural water, and sewage. Likewise steel pipe has been used for various types of installation – ranging from orindary buried pipelines to crossings under rivers, roads, and railways, and from aqueduct bridges to submarine lines supplying water to offshore islands. Today approximately 100,000 tons of steel pipe are installed annually as water mains. Particularly in large-diameter water mains 1,000 mm and over in O.D., more steel pipe is now being used than ductile cast iron pipe, which has the longest history as water pipe.

Behind the wide acceptance of steel pipe as superior piping material has been the progress in pipemaking processes, field welding and corrosion protection techniques, and design methods that take advantage of the properties of steel pipe.

Among these developments, this paper focuses on the present and future of design technology and presents several installation examples.

2. Properties of Steel Pipe

Water lines may be constructed of pipe made from steel, cast iron, Hume concrete, asbestos, PVC or other materials. Steel pipe possesses properties that distinguish it from the other piping materials in two ways. First, steel pipe shows a large elongation in the plastic rang eof the material and has high toughness. More specifically, steel pipe does not necessarily crack or rupture when subjected to loads that exceed its yield strength or even its maximum bearing capacity; steel pipe also exhibits extremely high impact resistance.

Second, steel pipe is joined length to length by welding, in contrast with mechanical joints that use, for example, rubber rings for watertightness. Steel pipe, therefore, does not have the problem of joints slipping out of place or leakage from joints, and thus forms a flexible, continuous line.

These properties of steel pipe can be taken advantage of to design and build more reliable and economical pipelines than before. In fact, this approach is being increasingly adopted in Japan and will spread further in the future. Application of this concept in actual design will be discussed in Section 3 of this paper. The elastoplastic characteristics of steel pipe will now be briefly explained by taking examples from typical load conditions.

2-1. Tensile Load (1)

When subjected to a tensile load in the axial direction, pipe stretches elastically (elongation is proportional to the load applied) until stress (strain) reaches the yield point of the material. At a further increased load, the pipe shows uniform elongation without any reduction in the wall thickness until strain reaches a certain amount. As the strain increases above this level, the wall thickness begins to decrease and the pipe necks down and eventually breaks. Typical tensile test results for steel pipe are shown in Table 1.

Table 1 Example of Steel Pipe Tension Test Results
Specimens : STPY41, 609.6mmx6mm

	Pipe Specimens		Material Test Piece
	With welded sections	Without welded sections	
Uniform Elongation	24.6% (Welded section 12.6%)	22.3%	20.6%
Maximum Load	500.6 tons	541.6 tons	

Table 1 reveals that steel pipe has very large elongation, with uniform elongation being in a range above 20% strain (above 10% for welded sections).

2-2. Compression Load(1)

When subjected to a compressive load in the axial direction, pipe shrinks elastically until stress (strain) reaches the yield point of the material. As the load is increased further, the stress-strain curve enters the plastic range of the material, and the maximum bearing capacity is reached at a certain amount of strain; thereafter, the bearing capacity decreases, eventually resulting in local buckling. Typical compression test results for steel pipe are shown in Table 2 and Photo 1.

Table 2
Typical Compression Test Results for Steel Pipe
Specimen: STPYAL 609 6mm x 6mm

	Strain	Compression Load
Maximum Bearing Capacity	0.542%	350.5 tons
Local Buckling	0.738%	255 tons

Example of Steel Pipe Buckling under Compression

2-3. Plastic Range Low-Cycle Fatigue Test(2)

Table 2 and Photo 2 show a result of plastic range low-cycle fatigue tests in which the effects of earthquakes were taken into consideration with regard to the seismic design method discussed later in this paper.

Table 3 Typical Fatigue Test Results for Steel Pipe

Specimen No.	Strain Amplitude εa (%)	Period T (sec)	Number of Cycles N
(W) 1	0.30	3.30	1,832
2	0.32	3.30	[illegible],748
(W) 3	0.48	0.50	380
4	0.40	0.50	1,064
(W) 5	0.50	0.50	272
6	0.65	0.50	193
(W) 7	1.00	1.00	48
8*	0.30	0.33	1,834

Notes:
1. Symbol W indicates a specimen that contains a welded section at center.
2. Asterisk * indicates testing at an internal pressure of zero; others tested at an internal pressure of 10 kg/cm^2.
3. Specimen is SGP100A (Do = 114.3 mm; t = 4.5 mm; L = 400 mm).
4. Cycles N indicates the number of cycles of loading until leak is found.

Fatigue Failure of Specimen No. 1

The test results show good agreement with the "best fit" curve in ASME Sec. III. Also, as shown in Table 3, leak was observed at 1% strain amplitude and 48 cycles of loading with 1-second periods or at 0.3% strain amplitude and 1,832 cycles of loading with 3.3-second periods, thus revealing that the material has sufficient fatigue characteristics.

2-4. Circumferential Deformation Characteristics(3)

When load P acts upon steel pipe, as shown in Fig. 1, the pipe deforms elliptically. Behavior of the pipe under this loading condition is explained by referring to Fig. 1.

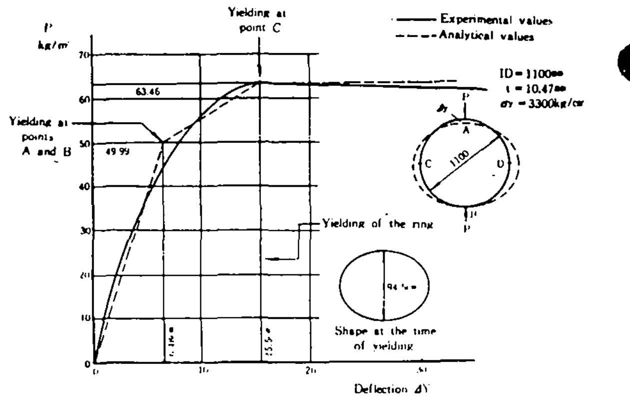


Fig. 1 Typical Linearly Loaded Flattening Test Results for Steel Pipe

As P is increased gradually, bending moment at points A and B reaches the yield moment first (the whole cross section at points A and B yields to bending and becomes plastic hinges). When P is increased further, the bending moment at points C and D reaches the yield moment, and four points of A, B, C and D become plastic hinges. Maximum load is reached at this time, and the deformation progresses even if the load is no longer increased.

In actual design this deformation characteristic of steel pipe under load is closely related to the design of buried pipe in the circumferential direction. With actually buried pipe, however, the yielding phenomenon does not occur as clearly as it is observed in experiments. This is because buried pipe is influenced by the reaction force of the soil around the pipe. It has been reported that the relationship between load and deformation is linear until the deformation ratio reaches about 15%. (4)

The foregoing has been a brief introduction to the typical behavior of steel pipe in the plastic range. It has been shown that steel pipe has excellent properties that make it possible to design economical and highly reliable pipelines.

The next section will discuss the seismic design of buried steel pipe that is based on allowable strain in the plastic range of the material. This will be followed by an introduction of the present state and future prospect of the rational circumferential pipe design based on the mechanism of pipe behavior under internal and soil pressures acting on the pipe simulatnesouly.

3. Design of Steel Water Pipe

3-1. Seismic Design

(1) *Earthquakes in Japan*

Most earthquakes take place in belt zones along the continental and island coasts around the Pacific Ocean, and these zones constitute what is known as the circum-pan Pacific earthquake belt. Situated in this earthquake zone, Japan has been hit by large earthquakes many times. Historial records show that almost all earthquakes of magnitude eight on the Richter scale in Japan have occurred in this Pacific zone. These large earthquakes are regional and take place at a frequency of from several decades to one hundred and twenty or thirty years. The location of tectonic plates and occurrence areas of large earthquakes around the Japanese archipelago are shown in Fig. 2.

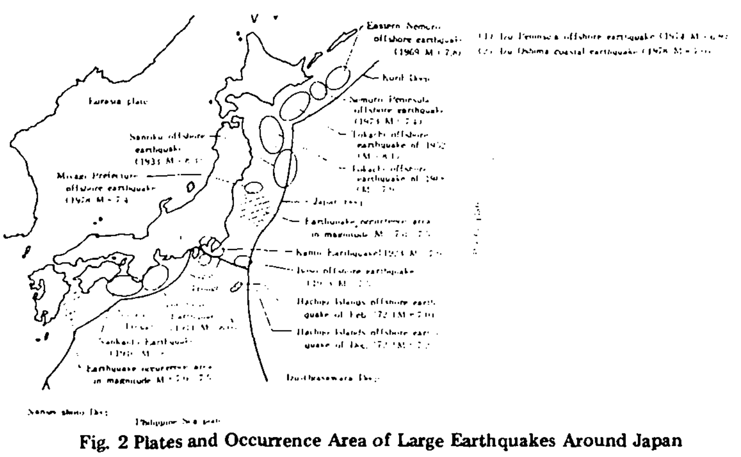


Fig. 2 Plates and Occurrence Area of Large Earthquakes Around Japan

(2) *Outline of buried pipeline damage by earthquakes* (5)

To ensure that a pipeline is safe against earthquakes, it is desirable to carry out seismic design and plan earthwork and installation methods in the light of careful analysis of actual seismic damage to pipelines. Seismic damage is outlined here in relation to pipe material and laying conditions using examples from several past earthquakes on which a fairly large amount of data is available.

Typical damage in relation to pipe material is as follows:

(i) Centrifugal reinforced concrete pipe: Cracks in pipe, breakage of joints.
(ii) Cast iron pipe: Axial cracks in the case of pipe 400 mm or over in diameter, and breaks in pipe 350 mm or below in diameter; shear ruptures in Tees and cross assemblies, and separation of joints in bends.
(iii) Asbestos-cement pipe: Breaks in pipe and separation of joints.
(iv) PVC pipe: Mostly cracks and breakage in joints, branches and bends, with few breaks in pipe.
(v) Steel pipe: Cracks and breakage in the poorly welded portions, with only slight damage in pipelines welded according to normally adopted practices.

For damage which is relevant to pipe laying conditions, the following portions are found to be prone to damage:

(i) Specials such as Tees and cross assemblies.
(ii) Riser sections of aqueduct bridges, on-bridge crossings and other like pipe installations.
(iii) Sections where the pipeline is connected with structures.
(iv) Continuously laid sections of specials.
(v) Valve flanges.

Beside the above special sections of pipelines, damage also occurs in the portions of lines laid under unfavorable conditions, such as:

(vi) Those laid on weak ground and those laid over an area with locally different soil characteristics.

(3) *Seismic design of buried pipelines*

(a) Response displacement method

Numerous observations, experiments and analyses have confirmed that the behavior of a buried pipeline at the time of an earthquake is greatly influenced by the earthquake-induced ground movement around the pipe. In this respect, pipeline behavior is different from the behavior of such structures as bridges and buildings, which are influenced by the acceleration of seismic motions. Seismic design of a buried pipeline is therefore performed by using the response displacement method – a method in which the response displacement amplitude of the ground due to an earthquake is calculated and then strain is transmitted to the line with the ground restraint on the pipe modelized as a spring.

In Japan, this approach to seismic design was first adopted in 1974 as it was stipulated in the Technical Criteria for Petroleum Pipelines (draft). The basic concept of this design method was then adopted by the Japan Water Works Association in its Guidelines and Explanations Concerning Earthquake-Resistant Construction Methods for Waterworks 1979.

The seismic design flow chart based on the response displacement method is shown in Fig. 3. Typical calculation results obtained by the response displacement method are shown in Fig. 4.

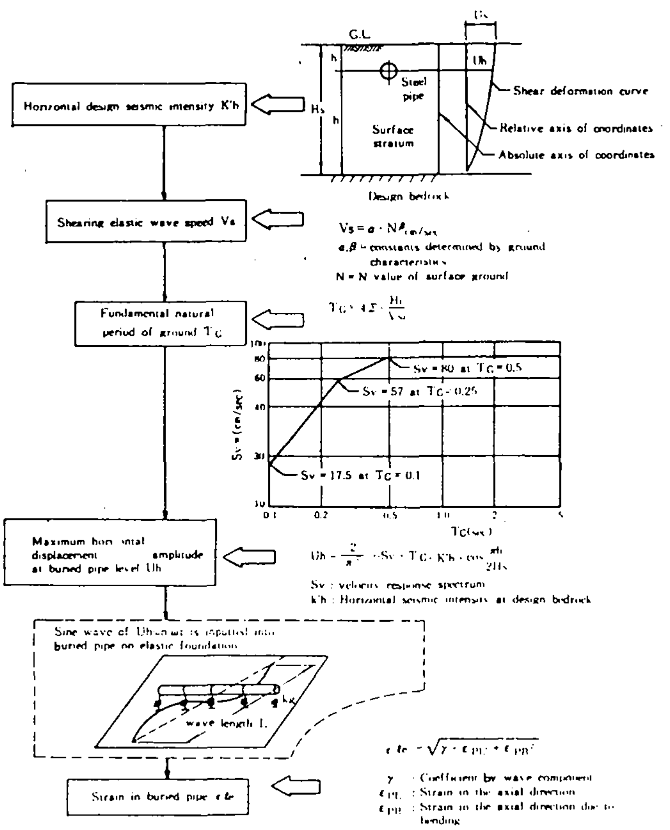


Fig. 3 Calculation Flow Chart by Response Displacement Method

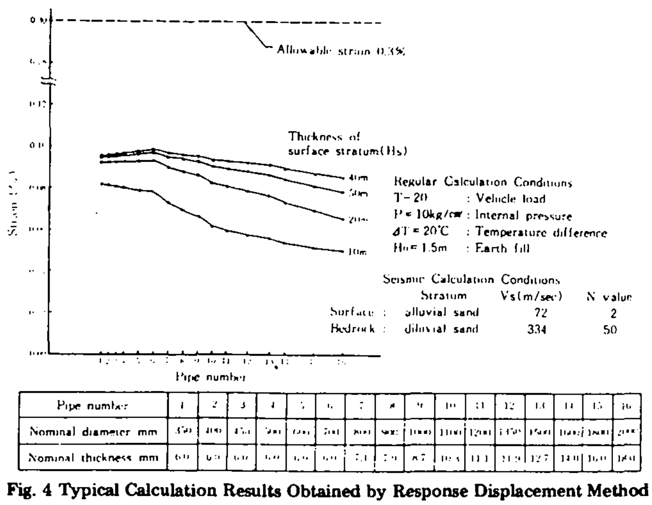


Fig. 4 Typical Calculation Results Obtained by Response Displacement Method

These results show that a very large strain is induced in the pipe in the axial direction by seismic motions, and this characteristic of seismic forces acting upon the pipe explains why the types of seismic damage mentioned earlier – separation and breakage of joints (in joined pipelines) and breakage of screws (in screw-joined steel pipelines) – are most common.

(b) Allowable strain of pipe at time of an earthquake

Records show that welded steel pipelines are only slightly damaged by earthquakes and can be considered to be highly aseismic. As discussed in Section 2, steel pipe has high deformability in the plastic range and does not immediately break even when subjected to forces above its yield strength.

Straight steel pipe, for example, has the characteristic of uniform elongation more than 10% even in the welded area. At the time of local buckling under compression, moreover, steel water pipe most widely used in Japan (D/t ñ 110) exhibits a strain of as much as 0.6%.

These characteristics have been elucidated by tests and analyses using full-size pipe specimens. In 1978, in its Technical Guideline for the Seismic Design of Buried Steel Water Pipes, the Japan Water Steel Pipe Association proposed an allowable design strain in the case of an earthquake of 0.3% for steel pipe. This proposal was then adopted in the Japan Water Works Association's Guidelines and Explanations Concerning Earthquake-Resistant Construction Methods for Waterworks 1979 as an allowable design strain for steel pipe against earthquakes of a large magnitude that occur very rarely.

This allowable strain of 0.3% represents a safety factor of 2 on local buckling, and 30 on uniform elongation.

(4) *Future of seismic design*

The response displacement method, which came to be generally used in Japan around 1974, ahs solved many difficult design problems associated with earthquakes and has made it possible to design some sections of buried pipelines aseismically. As a result, the intrinsic properties of steel pipe have been highly rated, and allowable strain in its plastic range has now been accepted. As indicated by the examination of earthquake-caused damage, however, several problems still remain with regard to specials, connections with structures, and pipe section crossing soils of different characteristics. Therefore, design procedures for those pipeline sections for which authorized methods are not yet available must be established, for example, by adopting an appropriate method of dynamic analysis based on earthquake observations.

3-2. Rational Design in the Circumferential Direction

Design of buried pipelines involves not only calculations in the axial direction of the pipe, as discussed under Seismic Design above, but also calculations in the circumferential direction. The latter aspect will now be discussed.

The primary objective of circumferential design for buried pipelines is to check whether the pipe is safe against loads, such as soil pressure, that act upon it. To calculate soil pressure on buried pipe, the soil pressure distribution diagram proposed by Spangler and Marston is most widely used today. In 1979, the U.S. Bureau of Reclamation introduced the E' value, a reaction coefficient of soil proposed on the basis of extensive field measurements and laboratory tests. As a result, the design reliability of Spangler's soil pressure diagram has been increased. In 1980, the concept of this design formula was adopted in its entirety by the Japan Water Steel Pipe Association as a guide for calculating wall thicknesses. At the same time, more precise explanations of the characteristics of buried steel pipe behavior were incorporated in an effort to further enhance design reliability. These developments are briefly described below.

(1) *Design for simultaneously acting internal and external pressures*(4)

Water pipe is usually subjected to both internal water pressure and soil and other external pressures. Generally, however, internal pressure acting to restore pipe deformation due to external pressures is considered to be a design factor conducive to the safety of the pipeline. Therefore, it is not taken into account together with external pressures. Spangler also already analyzed pipe behavior under internal and external pressures. Bending stress in pipe when subjected to internal pressure P and soil pressure W is expressed by

$$o_b ñ \frac{2aW}{Z} \frac{K_bR^2EI}{E1} ¡ \frac{(0.061K_b - 0.083K_x)\,E'R^3}{0.061E'R^3 \quad 2K_xPR^3} \quad \text{--- (1)}$$

From Equation (1), bending stress o_b decreases as internal pressure P is increased, as shown in Fig. 5.

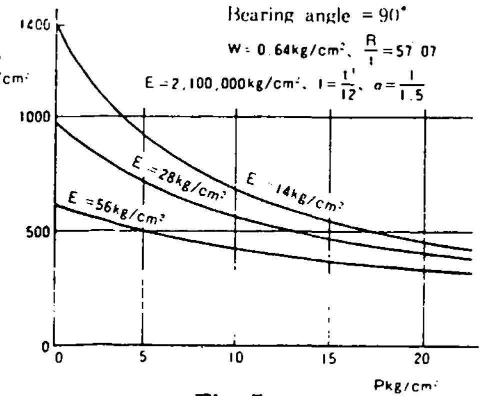


Fig. 5

Reduction of Bending Stress due to Rise of Internal Pressure: Calculation Example of Equation (1)

When bending stress and tensile stress are acting simultaneously, the yield limit of steel is expressed by the equation (see Fig. 6)

$$\frac{o_b}{o_Y} = 1 - \left(\frac{o_t}{o_Y}\right)^2 \quad \text{--- (2)}$$

where o_Y = yield point of steel

This equation represents the basic design concept applied in ASME Code, Sec. III (standard for nuclear reactor equipment and piping systems). When a certain safety factor, B, is provided for this yield limit, the hatched range plotted in Fig. 6 is obtained as an allowable range defined by safety factor B.

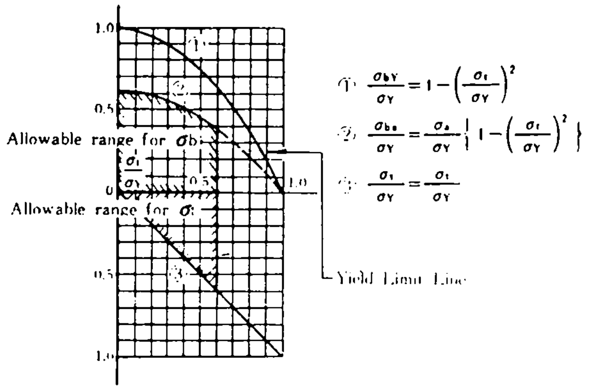


Fig. 6 Yield Limit and Allowable Range

When the yield limit and allowable limit diagram in Fig. 6 is superposed on Fig. 5 after several calculations, Fig. 7 is obtained. From Fig. 7, the following will be understood:

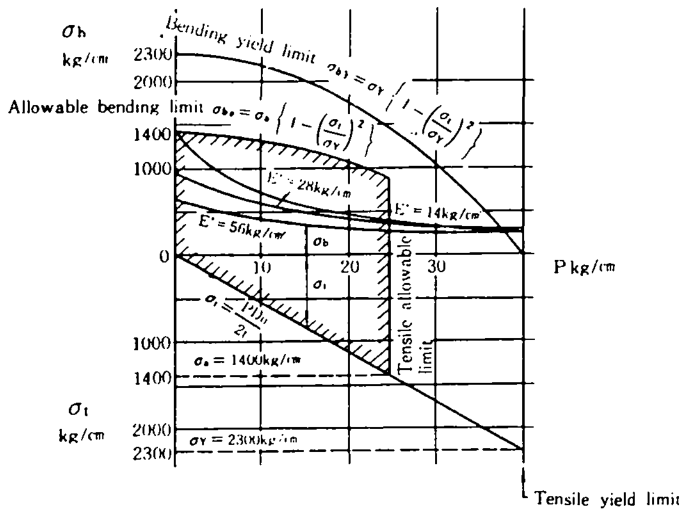


Fig. 7 Stress Due to Simultaneous Action of Internal and External Pressures

(i) The allowable range is within the hatched area, and Fig. 7 reveals that the allowable range for $o_b + o_t$ is not constant.

(ii) Since bending stress decreases with the rise in internal pressure, pipe with D/t = 114, as shown in Fig. 7, if designed at internal pressure = 0, is safe against internal pressure levels of up to about 25 kg/cm^2.

The above concept and calculation formulas can be used to ensure safe and economical design for high-pressure pipelines, and safe design can be ensured for normal pressure pipelines by determining the required wall thickness at internal pressure = 0.

(2) *Ultimate strength of buried steel pipe*

Japan Water Steel Pipe Association's design criteria stipulate an allowable stress of 1,400 kg/cm^2 in terms of an axial stress (41 kg/mm^2 tensile strength steel, yield point σ_Y = 2,300 kg/cm^2, safety factor for σ_Y = 1.6) and an allowable deformation ratio of 5% against stress and deformation by earth-fill pressure. Steel pipe used under normal burial conditions in Japan has a D/t ratio of about 110. The ovaling of steel pipe with such D/t ratios increases as soil pressure increases, and plastic hinges are formed on the bottom, top and sides of the pipe; however, because of the effect of the reaction of the soil around the pipe, the pipe is expected to continue its linear behavior until a fairly large deformation ratio is reached. [4] Phenomena indicating pipe instability, such as buckling, will not be observed.

It was assumed that the ultimate strength of pipe is reached when plastic hinges form at four points of the pipe – the top, bottom and sides. The soil pressure at this time was determined and safety factor Sf was calculated from the ratio of this pressure to the soil pressure under which the allowable stress is reached. Calculation results are shown in Table 6.

Table 4 Safety Factor for Buried Steel Pipe

Bearing angle 90° $\frac{R}{t}$ = 57.07												
σ_Y= 2300kg/cm	E'	0	3.5	7	10	14	20	28	40	56	70	100
σ_a= 1400kg/cm	$Sf = \frac{W_Y}{W_a}$	1.7	1.79	1.84	1.88	1.94	2.02	2.13	2.27	2.46	2.63	2.94

As shown in Table 4, safety factor Sf = 1.7 was obtained even at E' = 0, and Sf = 1.9 was obtained at E' = 1.4. These safety factors are approximately the same as those for such structures as bridges, and can be considered to be sufficient within the scope of currently available design methods based on Spangler's soil pressure distribution.

(3) *Future approach to circumferential design*

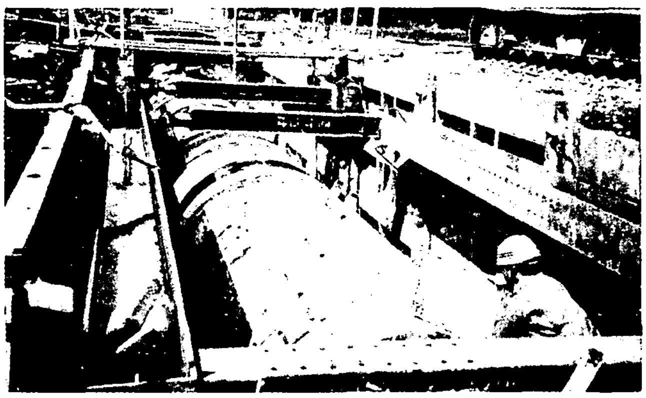
The safety of steel pipe designed by using state-of-the-art technology has been discussed. Judging from laboratory test results and field experience, however, actual safety factors are much higher than the values in Table 6, and may even be excessive. As already mentioned, steel pipe exhibits large elongation in the plastic range, and it is important to make the best use of it in designing pipelines. Since the mode of pipe rupture varies with the D/t ratio of pipe and the degree of soil compaction (or level of E'), it is important to clarify the rupture mode through analyses and experiments by using the elastoplastic finite element method and then incorporating analytical results into actual design through constant information feedback. In this way, the excellent properties of steel pipe can be put to better use in future designs.

4. Examples of Water Steel Pipeline Projects

Some interesting water steel pipeline projects are introduced below.

4-1. Ordinary Buried Pipeline

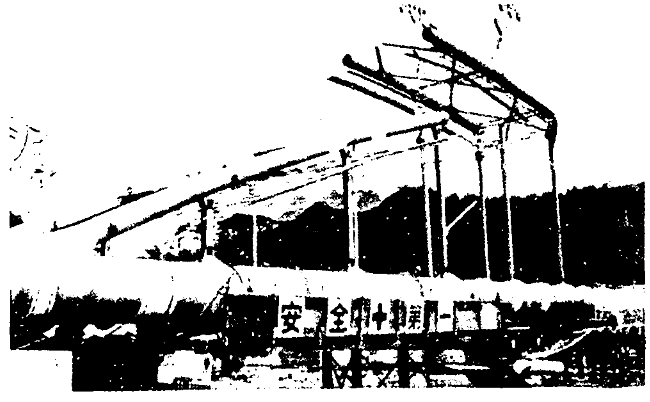
This pipeline, which supplies water to a wide area in Sendai, Miyagi Prefecture, is 2,400 mm in diameter and has a design internal pressure of 25 kg/cm^2. Since there have been large eathquakes in the Sendai area, the pipeline was designed in accordance with the Japan Water Works Association's Guidelines and Explanations Concerning Earthquake-Resistant Construction Methods for Waterworks 1979.



Buried high-pressure pipeline

4-2. Aqueduct Bridge

This aqueduct bridge was constructed as part of a main that supplies water to a wide area in Kawanishi, Hyogo Prefecture. It is a Langer-type bridge with a pipe diameter of 1,350 mm and a span length of 83.3 meters. Since the site space was limited, it was impossible to construct temporary piers. Therefore, the aqueduct bridge was constructed by the cable erection method.



Langer-type aqueduct bridge

4-3. Water Main Inside a Submarine Shielding Tunnel

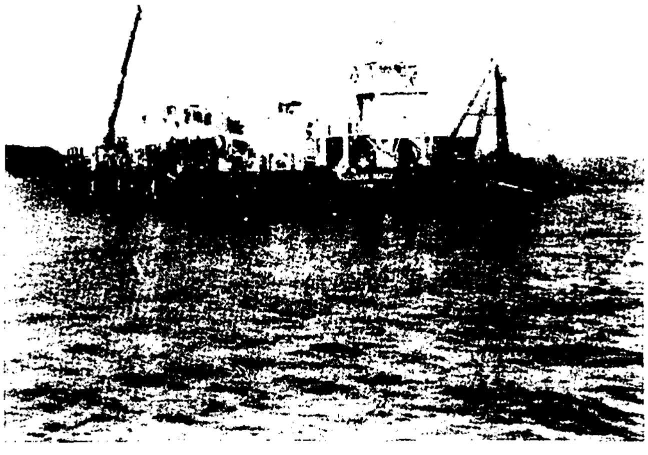
This water main was laid inside a 3.7 meter diameter submarine shielding structure that stretches approximately 2,000 meters across the bottom of Nagoya harbor. The main is 2,500 mm in diameter. It was decided to lay the main inside a shielding structure in consideration of all conceivable problems, including those related to sea traffic and the maintenance and safety of the main.

Water main inside a submarine shielding tunnel

4-4. Submarine Water Transmission Line

Among the many submarine oil, gas and water pipeline projects undertaken by Nippon Steel, two water transmission pipelines are introduced below.

A submarine pipeline off Matsushima, Nagasaki Prefecture, was laid by the lay barge method. The pipeline is 250 mm in diameter and 2,700 m long. Automatic TIG welding machines were used for this project.



Lay barge

Submarine water pipeline under construction

A pipeline 1,500 mm in diameter and 1,900 m in length was laid on the bottom of Lake Biwa. In laying this line, pipe was welded length to length to form approximately 480-meter blocks. Then it was towed to the laying route, where it was flooded and submerged to position.

1,900 meter pipeline being loaded and submerged to position

5. Conclusion

Effective utilization of resources and energy has become a social issue of primary significance. As a result, requirements for water pipelines have grown increasingly severe both in quality and reliability, and technological development efforts are being made in every area from pipe making to pipe laying. This paper has presented recent advances in pipeline design technology. There are other areas that are equally important, such as pipe welding and corrosion protection technologies. Needless to say, technological evaluations are being made in all these fields.

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EFFICIENT OPERATION AND MAINTENANCE OF THE DISTRIBUTION SYSTEM IN OSAKA

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1. Introduction

The distribution system is one of the fundamental facilities in a waterworks. But the distribution system has many difficult problems in almost every utility – for example, low pressure, red-waters, water leaks, vast energy consumption especially at pumping stations, and insufficiency of earthquake-protection facilities. So we must always make every possible effort to improve the efficiency of operation and maintenance of the distribution system.

This paper discusses the problems of the distribution system in Osaka, Japan, and our countermeasures, explaining mainly the "block system" and several effective techniques for maintenance.

2. Outline of Waterworks Facilities of Osaka

The city of Osaka has a 2.7 million population, 1.1 million households and a $210Km^2$ area at present. Our utility, first starting water supply in 1895, has now three purification plants, 13 pumping stations and a total length of 4,640 Km of pipelines (of 75 mm diameter and above). This excludes the industrial water supply system. The total capacity of the three purification plants is 2.43 million m^3 per day.

2. Renovation and Replacement Project

The main problems of the distribution system in Osaka were low pressure, leakage of water and red-water in old pipes.

To cope with them, since 1972 we have carried out a ten-year renovation and replacement project costing about 81 billion yen, including laying new pipes, replacements, renovation of old pipes mainly with the epoxy-resin lining method mentioned later. Tab. 1 shows the items of the project and Tab. 2 shows the results.

As a consequence, low pressure has been completely cleared and red-waters have been reduced to half. Metered-ratio, accounted-for water, has been improved from 73.6% in 1971 to 88.1% in 1980 (Ministry of Health and Welfare cliams that metered-ratio is to be improved to 90% in Japan).

For more efficient operation and maintenance of the distribution system, we are aiming at still more improvement of metered ratio, energy-savings and reduction of the area suffering low pressure and red-waters caused by pipe fractures or valve operations.

To achieve these purposes, we are going to adopt the "block system" of pipelines and other effective techniques for maintenance of the distribution system.

4. The Block System

As for the layout of the distribution system, the gridiron system is the most common, particularly in large cities. Only in cities where there are considerable differences in surface elevation, the distribution systems are sometimes divided into zones in order to avoid excessive pressure in lower zones.

But the gridiron system has some defects. First, it is very difficult to find out the exact flow rate and pressure of water at each point, and sometimes even the direction of flow, in the distribution system. Secondly, the fluctuation of pressure and flow rate influences a very large area.

Therefore, we are now studying a new system instead of the common gridiron system, although there is little variation in surface elevation in Osaka. If the distribution system is divided into many blocks or zones, and each block is separated hydraulically, leaving specific connections to distribution mains at a few points, we can get many advantages for the operation of the distribution system. We call the layout of the distribution system mentioned above the "block system" or "zone system." The former is more commonly used in Japan.

The block system is able to effect many advantages for operation of the distribution system, with telemetering of the important information such as flow rate, pressure and sometimes residual chloride at various points to a central computer.

The advantages of the block system are as follows:

(1) *Various important data are directly obtainable*

If a meter and a pressure gauge are installed at each connecting point between a block and a distribution main, we can get the exact water-consumption and pressure in the block at any time we choose. So we can easily calculate and instantly prepare the quantity of water which must be supplied through the main pipe connected by the block. This is very valuable data for operation and maintenance of the distribution system, especially when planning extension of the facilities or construction schedules requiring a suspension of water supply.

(2) *Restriction of the suffering area*

When we operate many valves for an accident or construction, the low pressure and the red-waters are sometimes spread out to an unexpected extent. On the contrary, we used to estimate a relatively large area for red-waters and the low pressure caused by value operations for a construction, from the point of view of security, and sometimes we considerably over-estimated.

In both cases, many complaints will come to the utility. But in the block system, the suffering area is restricted to a small block and so the prediction of the area is accurate.

Moreover, in the block system, when an earthquake breaks out, the blocks damaged little can be supplied with water through the earthquake-proof distribution mains.

(3) *A countermeasure for leakage*

In the block system, if a pressure reducing valve is installed at the connecting point between a distribution main and a block, the pressure is easily reduced to the proper value and the amount of water leakage can be cut down.

Moreover, as a meter is installed at the connecting point, the unaccounted-for water in each block can be easily calculated. This datum is very useful for planning leakage surveys.

(4) *Energy saving*

In the block system, the distribution system is divided into the requisite number of blocks in accordance with surface elevation, and other geographical features, or the amount of water supply. Booster pumps for higher blocks can prevent many other lower blocks from excessive pressure, so the electric power consumption of pumping stations can be decreased.

(5) *Uniformity of water supply*

In a period of water shortage caused by dry weather, we water ave to restrict the quantity of water supply by valve operations. But in the gridiron system, the network of pipes is so complicated that it is very difficult to supply water uniformly all over the area in such a situation. Accordingly, in some regions, complete suspension of the water supply could occur.

But in the block system, the distribution system is simpler and it is relatively easy to supply water uniformly with simple valve operations.

However, the most serious disadvantage of the block system is that it is very difficult to reorganize the existing gridiron system into the new block system, especially in large cities. Many constructions must be done in the streets to cut and lay pipes and to install many valves and meters. Moreover, there are usually so much traffic in the streets that it is very expensive and time-consuming to complete the reorganization of the existing system.

The block system is a good method for effective operation and maintenance of the distribution system, especially combined with a telemetering system and a computer.

In Osaka city, we are going to divide the existing distribution system into 17 blocks and install 40 monitoring stations where flow rate and pressure of water are automatically measured and the information is telemetered to a central computer. We are intending to complete the block system mentioned above in an eight-year project.

5. Some effective techniques for maintenance of the distribution system

(1) *Renovation of old pipes*

A. Epoxy-resin lining (less than 300 mm diameter)

In Osaka, pipes which are less than 300 mm diameter amount to 84% of the length of all distribution pipes and are directly connected with domestic service pipes. So, renovations are particularly needed.

We started inside cleaning of unlined pipes in 1956, but it was not sufficiently effective in reducing the troubles. Consequently, the use of several lining materials are keenly investigated.

The conclusion, after various surveys and studies, was that epoxy-resin, consisting of base-paint and hardener, and mixed at the work-site, is the most practical and satisfactory material. Since 1971, this epoxy-resin lining method has taken the place of all others. Procedures consist of 7 steps – (1) preparation (2) preliminary cleaning (3) cleaning with a scraper (4) hot-air drying (5) lining (6) natural drying (7) flush and disinfection.

The remarkable merits of the epoxy-resin methods are as follows:

(a) The cost of the procedure is about 25% of that of replacement.
(b) Inconvenience to traffic or passers-by should decrease because only two pits are required in each working stretch at a time.
(c) The standard supply suspension period for the average 60-100 m length between two pits is only 8 hrs.
(d) The thickness of the lining is only 1 mm and the available cross-sectional area of pipe is not reduced.

The achieved total length of the epoxy-resin lining has reached more than 1,000 Km to date, and we expect red-waters to be eliminated by this method.

B. Pipe-in-pipe method (Water mains)

For renovation of old distribution mains, the pipe-in-pipe method is often adopted in Osaka.

Although it has disadvantages due to the insertion of a smaller diameter pipe into an existing main, it is nonetheless very effective as far as construction costs are concerned.

(2) *Retardation of pipe corrosion*

A. Epoxy power coating

The interior lining of small-diameter bends has not been sufficient for retarding corrosion and has caused red-waters.

Recently it is reported that epoxy powder coating is effective in retarding corrosion, so we have adopted it for less than 300 mm diameter bends and valves.

B. Adjustment of pH

To control corrosion, we have experimentally adjusted the pH of supplied water at one purification plant since 1971. That is, pH value is raised from 6.5 to 7.5 with line. It is very difficult to evaluate the direct effect of the pH adjustment compared with the increment cost of lime, but we think it has some effect so we will continue it.

C. Polyethylene encasement

This process, encasing pipes with polyethylene film in tube or sheet form, was first employed in an operating water system in 1958 in the United States. Since then, polyethylene encasement has been used as a soil-corrosion preventative in Canada, Britain, France, Germany, Japan and many other countries.

Research on several severe-corrosion test sites has indicated that polyethylene encasement provides a high degree of protection and results in minimal and generally insignificant exterior surface corrosion of cast-iron piping.

In Osaka, polyethylene encasement was first adopted in reclaimed land in 1968. Now it is adopted almost everywhere in Osaka, except for a small region with good soil.

(3) *Protection of piping from other utilities' construction accidents*

A. Detailed map

To protect water mains and branch pipes from other utilities' construction accidents, or to reorganize the existing gridiron system into the block system, it is very important to complete detailed maps of the distribution system which points out clearly the exact location of pipes, valves and other fittings under the street. We are now undertaking an 8-year project costing more than 1.5 billion yen, drawing up map-cover in 1/500 scale, covering 1368 sheets.

B. Common ducting

There are many pipelines and cables in the streets. If these lines, such as water mains, gas pipelines or electric cables and so on, are laid in one common duct, no accident should occur when constructions are made in the streets.

It is very expensive to construct the common duct but the extension of this method is increasing gradually in Japan from the stand point of safety-first.

(4) *A construction method for replacement*

*The driving method (Propulsion method)

In a busy street in a large city like Osaka, it is sometimes very difficult to adopt the open-cut method for replacement of water mains. In such a case, the driving method (propulsion method) is often adopted in Japan.

New type driving pipe made from ductile iron or steel has been invented recently for direct underground driving. Using this pipe, it is easy to drive less than 100 m distances, and with using intermediate jacks, the distance can be extended more than 200 m.

6. Conclusion

The block system has many advantages for operation and maintenance of the distribution system. And many techniques for maintenance of the distribution system are now being developed.

It is very expensive and energy-consumptive to construct and maintain the distribution system and it is very hard to improve the existing one because of the necessity of laying long pipelines in busy streets.

Therefore, special consideration must be taken to decide long-term policy regarding the layout and operation plans of the distribution system.

And it is also important to continually improve old and deficient pipes conscientiously adopting the various effective techniques.

If what I have discussed above proves at all useful for your own waterworks system, then we in Osaka will be most gratified.

Tab. 1. Renovation and replacement project in Osaka (1972-1981)

Item	Diameter (mm)	Length (Km)	Cost (million yen)
Laying of new branch pipes	300-150	502.6	18,740
Replacement	300-150	389.2	24,310
Renovation of existing mains	1,500-400	23.7	7,123
Laying of new mains	1,500-400	10.4	5,774
Lining of existing pipes	1,100- 89	880.2	14,026
Other items		46.6	10,899
TOTAL		1,852.7	80,872

Tab. 2. Results of renovation and replacement project in Osaka

Year	Metered-ratio (accounted-for water)	Low pressure* (household)	Red-water (household)
1971	73.6	11,273	8,039
1972	74.7	5,895	6,087
1973	76.7	10,895	8,910
1974	79.1	7,535	9,361
1975	79.6	14,640	9,928
1976	83.4	1,332	9,822
1977	84.9	1,865	7,803
1978	85.8	1,185	8,750
1979	86.9	20	7,835
1980	88.1	0	4,387

*under 1.0 Kg/cm^2

SAFETY MEASURES AND LEAKAGE PREVENTION OF WATER SUPPLY PIPES

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1. Introduction

This paper intend to introduce some of the safety measures for pipelines executed by Bureau of Waterworks, Tokyo Metropolitan Government (TMW) to prevent the accident of pipelines and decrease leakages in Tokyo Ward area.

More than 80 years have passed since TMW started supplying water.

Concentration of population and industries to Metropolis and modernization of citiznes life made a remarkable increase of water demand year after year except during World War II.

TMW has been continuing to promote expansion project ceaselessly to meet water demand increase. At present, TMW has a supply capacity of 6.23 million cu.m/d with 11 filtration plants, and there laid about 13,000 km of transmission and distribution pipeline, whose diameter is from 75 mm to 2,700 mm, in the road of Tokyo Ward area.

These extended pipes are constantly exposed to dangers of leakages due to various causes, such as the weight and vibration of vehicles running on the road, construction works in and around the road, ground subsidence, etc. Besides these physical factors, there are harmful chemicals that may be emitted from chemical plants, corrosive soil, electrolytic corrosion, etc., which may cause leakage.

Leakage accidents cause sometimes traffic impeding and flood. But most of leaks are hiding underground and their detection is very difficult and troublesome.

The rate of leakage is Tokyo is reported as 15.4% in 1980, which is equivalent to about 750,000 cu.m/d. The leakage of water means a great economic loss in view of water resources, labor, chemicals and electric power required for the production of purified water. That is one of the major problems for the water supply management of a large city.

2. Transmission and distribution mains and present state of water leakage in Tokyo Ward area

2.1. *Pipelines in Tokyo Ward area*

Table 1 shows transmission and distribution mains laid in the public road of Tokyo Ward area which have about 580 sq. km.

Most of the pipeline are of cast iron which have about 3 million joints. One thirds of joints are old socket and spigot joints, and the rest are mechanical joints. About 147,000 valves and 74,000 hydrants are attached to pipelines. Number of consumers are about 3.2 million and whole supplied water is measrued with flow meters installed to each service pipe.

Table 1
LENGTH OF TRANSMISSION AND DISTRIBUTION PIPES IN TOKYO WARD AREA (km)

Material / Diameter (mm)	Cast iron pipe	Steel pipe	Asbestos cement pipe	Total
distribution submain 75 – 350	11,162	62	633	11,857
distribution main 400 – 2,700	1,262	168		1,430
Total	12,424	230	633	13,287

2.2. *Present state of water leakage*

2.2.1. Water leakage rate in Tokyo Ward area

Figure 1 shows the present state of water leakage rate in Tokyo Ward area. It has been more than 80% immediately after World War II. It has decreased year after year after that, however decreasing trend is now lowering gradually in spite of TMW's efforts for leakage prevention devoting about 14 billion yen and 700 persons, one tenth of whole personnel of TMW every year.

2.2.2 Cases and quantity of leakage

Table 2 shows the number of repair works of leakages in Tokyo Ward area. Most of them are from service pipes. Table 3 shows the estimation of leaked quantity in Tokyo. That is, more than 98% of leakage escapes under the ground.

Table 2
REPAIR CASES OF LEAKAGE (Ward, Tokyo)

Diameter / Year	400mm - 2,700mm		75mm - 350mm		Service pipe		Total	
	Cases	%	Cases	%	Cases	%	Cases	%
1978	316	0.4	4,985	6.8	68,430	92.8	73,731	100
1979	256	0.4	4,720	7.0	61,291	92.6	66,897	100
1980	333	0.5	4,299	6.9	57,970	92.6	62,602	100

Table 3
ESTIMATION OF QUANTITY OF LEAKAGE

Year	1978		1979		1980	
Daily mean water consumption	4,943,500	100%	4,794,200	100%	4,636,400	100%
Leak (underground)	763,400	15.4	734,200	15.3	706,300	15.2
distribution submain, service pipe	102,800	2.1	703,300	14.7	679,600	14.6
distribution main	660,600	13.3	30,900	0.6	26,700	0.6
Leak (ground surface)	8,900	0.2	8,200	0.2	7,800	0.2
Total	772,300	15.6	742,400	15.5	714,100	15.4

2.2.3 Causes of leakages

Figure 2 shows number of leakages in 1980.

More than 70% of the leakages from distribution main (≧400 mm) are caused by looseness of socket and spigot joints and 42% of distribution submain (≦350) by the looseness of joints and cracks of pipes. These facts show, in any way, most of the leakages are occured in old pipelines. Joints looseness are considered to be caused by uneven settlement of ground.

The factors which may cause leakage accidents are listed in Table 4. Accident occurs as a result of one of these causes of some combination or them.

3. Basic idea for safety and some measures against pipeline accidents

At present, it is possible to ensure the safety of pipelines by taking account of factors which may influence the safety of pipelines and by taking properly some of following safety measures according to laying conditions of pipelines.

3.1 *Selection of pipe and joint*

3.2.1 Forces to be considered at the desgining of pipeline

Following forces and defromations should be taken account of at the designing of pipeline.

1) Forces to be considered at the decision of thickness of a pipe

a. Transverse direction,

Internal pressure; hydrostatic pressure, water hammer, hydrodynamic pressure (if necessary)

External pressure; soil pressure, vehicle's load

b. Longitudinal direction,

thermal stress, uneven settlement of ground, seismic force (if necessary)

Safety of joints against getting loose should be also checked by taking into account of longitudinal deformation.

2) Uneven settlement

At the connecting part between structure and pipeline, uneven settlement tends to take place as the result of insufficient compaction of backfill or land subsidence.

At this place like this, flexible joint should be properly installed according to the estimated uneven settlement value.

3) Protection of specials

Imbalanced force, caused by internal pressure, makes pipe joint loose at a bend, T-pipe or stop end of pipeline. Calculating this force, proper protection such as concrete block should be taken.

Table 4
CAUSES OF LEAKAGE ACCIDENTS AND SAFETY MEASURES

Causes of leakage accidents	Safety measures
o Natural causes;	
Pipe material – insufficient strength against external and internal forces	Selection of proper materials and joints
joint – insufficient performance (expansion, bending, etc.)	structural calculation of pipe estimation of joint performance
Valve's flange – insufficient water tightness packing – deterioration	improvement of shape of flange and rubber packing improvement of materials of packing
Uneven settlement of ground – ground subsidence – insufficient backfill	flexible joint sufficient compaction of backfill
Corrosion pipe-inside corrosion soil corrosion electrolytic corrosion	pH adjustment, internal coating external coating, wrapping with polyethylene sleeve, bolts and nuts with oxide film surface
Earthquake	earthquake resistant design
o Artificial causes; Increase of running of heavy vehicles, Construction work nearby	protection of pipe

3.1.2 Transmission and distribution mains

Cast iron pipes and steel pipes are used properly as water mains in Tokyo in consideration of their reliability of strength, tenacity, durability and workability of joints connection.

Cast iron pipes are mostly used as transmission and distribution mains in urban area, while steel pipes used as raw water mains or transmission mains.

Cast iron pipe

Although initial cast iron pipe (grey iron pipe) was brittle against impact force, but recent ductile cast iron pipe, which TMW has used since 1960, has almost the same strength and tenacity as steel pipe. Mechanical joints of cast iron pipe are flexible to a certain extent, but not necessarily resistant against longitudinal deformation caused by uneven settlement or earthquake. In cases where longitudinal deformation is expected so large that employing sleeves alone on the pipe is not enough to absorb it, there should be employed special joints which has flexibility within some extent and stopper to prevent pulling apart.

Steel pipe

Arc welding steel pipe has uniformly high strength and tenacity, while proper flexible joint might be necessary where thermal stress or other longitudinal stresses concentrate.

Flange joint

Flat rubber packing has been usually used at flange joint, where sometimes water happened to leak caused by inferior fastening of flange bolts and nuts or uneven settlement of neighboring pipes.

TMW uses such special flange and rubber packing as shown in Figure 5 and having good result. Furthermore, reinforced concrete protection of pipeline is to be performed in proper length both sides of valve chamber as a safe measures against uneven settlement.

3.1.3 Service pipe

The leaks out of service pipes are estimated to be more than 80% of total leakages. Therefore, it is essential to strengthen service pipes for the effective performance of leakage prevention work.

There have been used lead pipe and polyvinyl chloride pipe (only inside of housing lot) in Tokyo.

Accidents of service pipes are caused mostly by insufficient pipe strength, corrosion, defective branch and improper laying work.

In order to reinforce these week points, following safe measures are now undertaken in Tokyo.

1) Material of service pipe

Stainless steel (SUS 316, containing molybdenum) is selected as the most suitable pipe material among the various materials in consideration of strength, tenacity, durability and corrosion resistance.

2) Joint of service pipe

The joint used for stainless steel service pipe has flexibility within some extent and stopper against pulling apart.

3) Branch fitting

For branch of service pipe, there have been used ferrule, but leakage accidents often happened at branch points caused by inferior joint settings.

Special "saddle type ferrule" is selected as shown in Figure 4. Furthermore, at the bend of pipeline some combination of elbows are used to absorb deformation of pipeline.

3.2 Safety measures against earthquake

Japan is located geologically in the circum-pan-Pacific belt and is subject to frequent earthquakes. Since the Great Earthquake of 1923 that gave fearful damage to TMW many earthquakes have given considerable damages to many waterworkers in Japan.

The grounds, where earthquake possibly causes big damage, are alluvial plain, peat bog, reclaimed land, banking, border of between hard and soft stratum, sandy ground where groundwater level is high, etc.

Damages to pipelines are crack or breakage of pipe barrel or joint, breakage of specials at networks connection, slipping out of joints between pipeline and structure, breakage of hydrant on the ground, breakage of ferrule, etc.

System of earthquake proof measures of TMW consist of two parts; preventive and emergency measures.

The preventive measures is intending to estimate the damage, which might be caused by a great earthquake to waterworks, and to strengthen facilities to be sufficiently earthquake resistant.

The emergency measures are preparations for emergency water supply at earthquake, for temporary restoration of broken facilities and for the establishment of the emergency system of waterworks, that is, communication system, public relations, and so on.

Recent investigations explain about the earthquake's influence upon pipelines that displacements and deformations of surrounding ground are dominant to inertia force. Taking these results into consideration, a new earthquake resistant design method (Seismic deformation method) is developed, assuming that ground responses, that is deformations of ground, to the earthquake is transferred to pipeline. TMW uses this method to examine the earthquake resistance of the important mains.

3.3 *Safety measures against corrosion of pipe*

3.3.1 Pipe-inside corrosion

q Degree and rate of pipe-inside corrosion is different according to the kind of metal and the quality of water. If inside of metal pipe is not completely coated, lumps of rust will be formed year by year, decreasing flow rate and causing red water.

Factors concerning pipe corrosion are dissolved oxygen, temperature, electrical conductivity, acidity, pH, residual chlorine, etc.

As a countermeasure against corrosiveness of water, pH adjustment is done. TMW uses caustic soda as chemicals of pH control taking handling conditions into consideration.

3.3.2 Soil corrosion

Soils of coastal estuary, peat bog, reclamation land and the ground polluted by harmful industrial waste water, are corrosive.

The causes of soil corrosion are not completely investigated, however sulfuric acid reducing bacteria, macro cell effect created by non-uniform soil condition and the like are considered as major factors.

TMW is making it a rule to measure following three factors as the criteria of soil corrosiveness.

Resistivity	≦ 1000	-cm
pH	≦ 4.5	
Redox potential	≦ 200 mV	

As a countermeasures against soil corrosion of cast iron pipes, TMW is wrapping the pipes with polyethylene sleeves and using bolts and nuts coated with oxide film.

3.3.3 Electrolytic corrosion

Electrolytic corrosion is caused by stray current in the ground, which mainly comes from the rail of direct current type electric railway. If pipeline is laid near electric railway, its substation or car shed, some safe measures against corrosion shall be needed.

As a countermeasures for that, semiconductor type selective drainage is usually used, because it is simple and economical.

In the case of cast iron pipeline, electrolytic corrosion proof is done by keeping good conductivity, with bond wire if necessary, and setting excluder at proper place.

When steel pipeline is laid over the long distance, stray current tend to flow into there, TMW makes it a rule to set a excluder at proper place and cover outside of pipes with reliable coating.

3.4.1 Reinforcement of pipeline system

1) Mutual connection between different systems

Tokyo Metropolitan Waterworks consists of plural water sources and 11 filtration plants as shown in Figure 5 TMW improved the safety of total system by mutual connection between different trunk line systems with large diameter pipeline. With this, whenever operation of any filtration plant is forced to reduce, because of power suspension or summer drought, then other plant can supply water in turn.

2) Block systematization of distribution pipe networks

A block system of pipe networks is to form networks, as shown in Figure 6, so that suspension of water supply due to damage may be confined to a minimum and restoration works easily carried out. Furthermore, by installing flow meter at the inlet pipes of every block system, the quantity of supplied water can be managed.

Many cities in Japan are making their efforts to build up distribution networks system in this way.

3) Rationalization of water supply

It is desirable to keep water pressure in proper level, because excessive high pressure is possible to cause leakage accidents. For this reason, supply area should be properly divided into some parts in consideration of trunk line system, ground height, topography, etc., and if necessary, booster pump or pressure-reducing valve should be installed.

TMW established The Water Supply Operation Centre in 1979, for the purpose of high utilization of limited water sources by means of rationalization of total water system. As for distribution control, The Centre has telemeters at 215 key points in supply area and monitoring running condition of facilities, flow rate, water pressure, etc. The data collected are analized through EDPS, and then optimum control is to put in practice.

4. Safety measures of pipeline on the stage of maintenance

4.1 *Safety measures against water leakage acci-*

The accident of a large diameter water main sometimes causes flood and land subsidence on the ground surface.

About 40 significanct accidents ilke this and

About 40 significant accidents like this and more than 1,000 more slight ones occur in Tokyo Ward area every year.

TMW disposes "Special task party" of which duties are public relations for inhabitants and emergency water supply for water suspension area. And also experts are always stand ready for emergency valves handling at every branch offices. TMW makes it a rule to repair the damaged pipe without delay with the cooperations from contractors.

4.2 *Detection and repairs of underground leakages*

Underground leakage, escaping stealthily, accounts for more than 98% of total leakage, but its detection is extremely difficult. Therefore, every effort is being made to detect and repair leaks, according to a program of inspecting all areas (consist of about 4,000 blocks) in a two-year cycles.

Leakage detection work is done at midnight with sound detector and other instruments.

TMW developed a new leakage estimation method (minimum flow method) and applying it to leakage detection work for the measurement of leakage in every block area without difficulty.

4.3 *Replacement of old distribution pipes with new ones*

As stated above, detection and repair of underground leakage have only a little effect as for decrease of leakage. To improve this situation radically, TMW has been replacing old distribution pipes with new ones since 1972. The 1,600 km of old pipes are to be replaced in total.

4.4 *Protection of old pipe joints and refreshment of old pipelines*

4.4.1 Protection of pipe joints

Most of the leakages from distribution main is caused by looseness of socket and spigot joints. Socket joints can be protected with special fittings from both outside and inside.

In case of large diameter pipe (>800 mm), and if it is possible to cut off water, inside protection is more economical than outside one.

4.42 Refreshment of old pipeline

Refreshment of old pipeline is to refresh old pipes by coating their inside with new lining or by inserting new pipes into old pipe line. It is effective for the decrease of friction loss and red water, and by far more economical than replacement of old pipeline. TMW is adopting refreshment of pipe at such place where construction work by open cut method is difficult to do, and there is no problem to the function of pipeline.

Some of the pipe refreshment method are as follows;

1) Pipe refreshment

This method is adopted for pipeline of which strength is sufficient, but many lumps or layers of rust is formed inside of pipes.

After cleaning and removal of rust, inside of pipe is coated with epoxy resin lining.

2) Pipe-in-pipe method

After cleaning of pipes inside, new pipe of which diameter is smaller about 100 mm than old one, put into old pipeline and then grouting is applied to the gap between old and new pipes with cement milk or so.

4.5 *Development of leakage prevention technology*

Leakage prevention is equivalent to the development of new water resources. Under present condition, getting worse for leakage prevention work year by year, TMW set up Leakage Prevention Technology Laboratory in 1974 and since carrying on research.

As a result, some new technologies were developed and practiced as follows;

a. Leak estimation by "Minimum flow method"
b. Development of special car for measuring of minimum flow
c. Development of sound recording type leakage detector
d. Pipe joint protection method
e. Stop of water by pipe freezing

5. Conclusion

Safety of water main and leakage prevention are the most important and urgent problem to the large city waterworks for the promotion of effective use of finite and precious water resources.

In case of newly laying pipeline, it is possible to estimate probable causes of accident from laying condition of pipeline and secure safety by taking safety measures as explained in 3. These basic ideas of safety can also be effective guidelines for maintenance works of pipeline.

But nowadays, leakage prevention is getting more and more difficult especially in large cities.

Replacement of old pipes with new ones are most radical and effective way for leakage prevention, but it will require a long time because of the limitation of finance, conditions of pipe laying and executive ability of waterworks.

Therefore, most practical way should be that; executing positive safe measures such as reinforcement, replacement or refreshment of pipeline on one hand, persistent and unceasing efforts for the efficient detection and repair of leakage should be continued as much as possible on other hand.

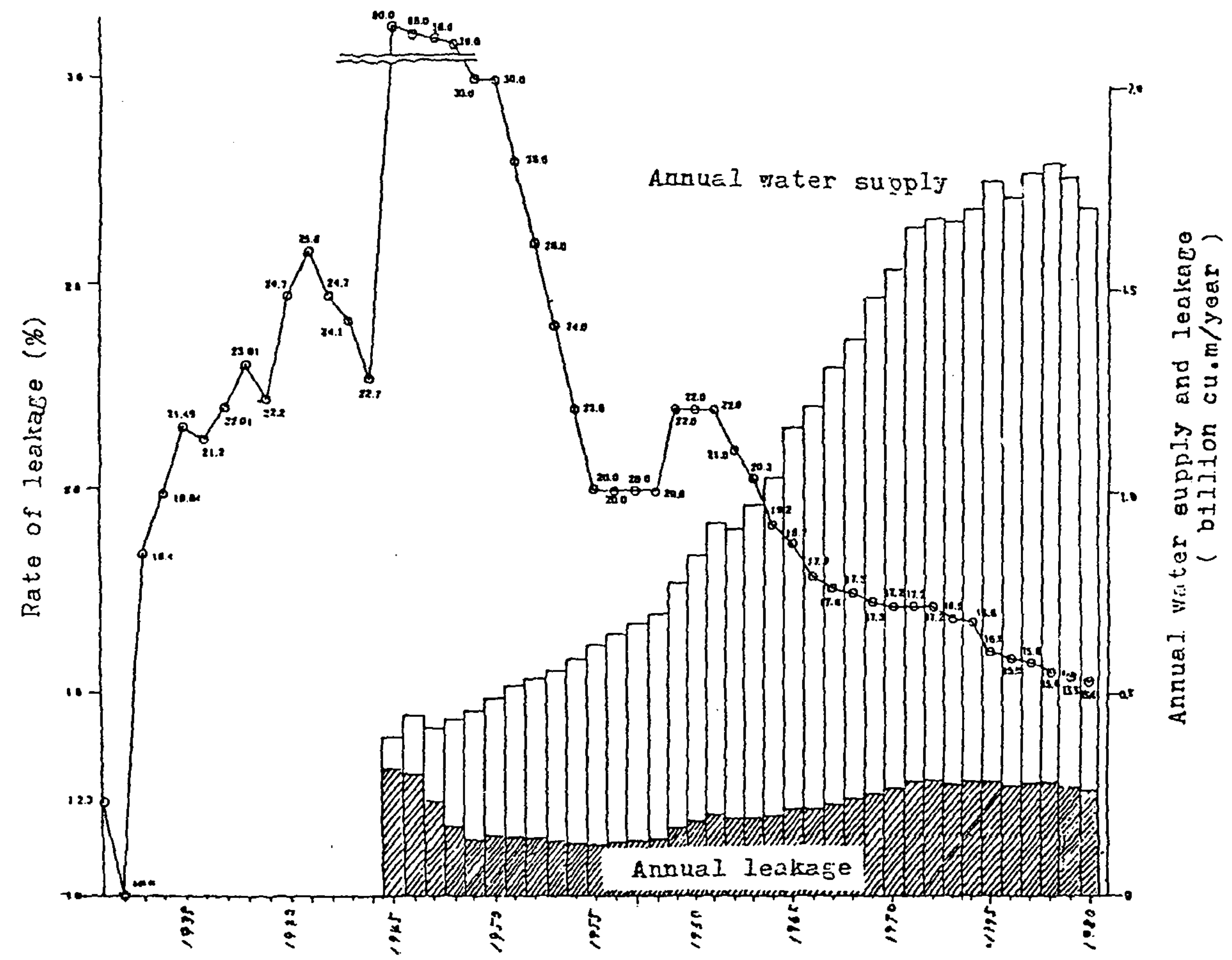

Figure 1. Recent water leakage rate in Tokyo

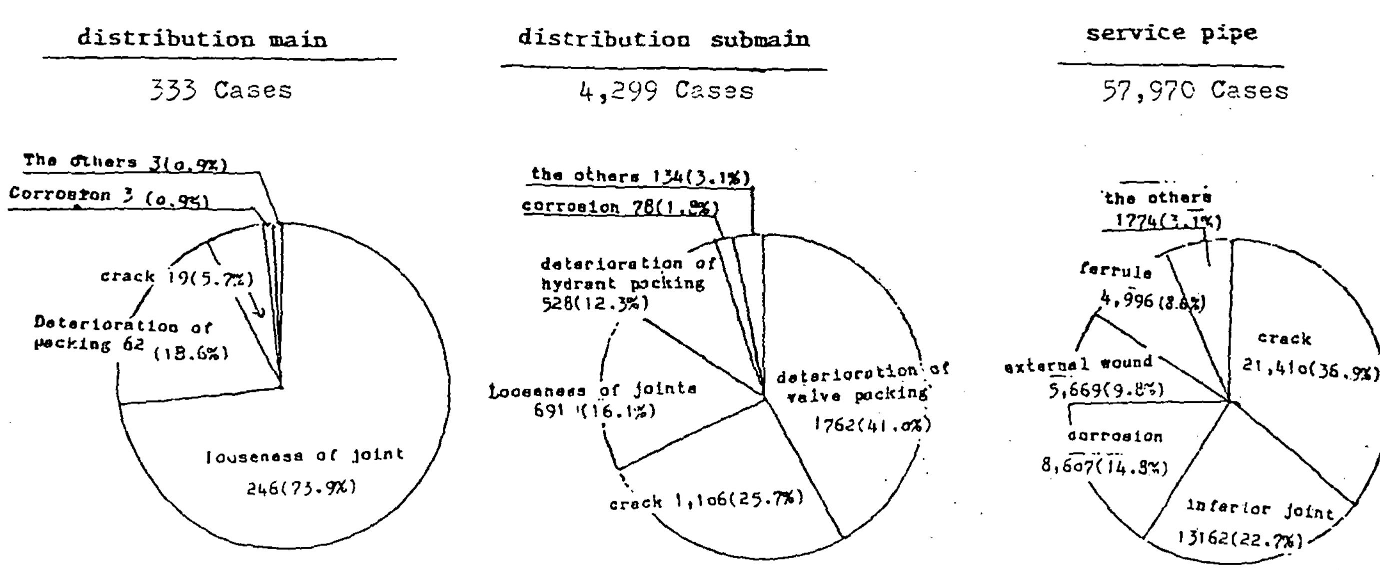

Figure 2. Number of leakage accidents in 1980

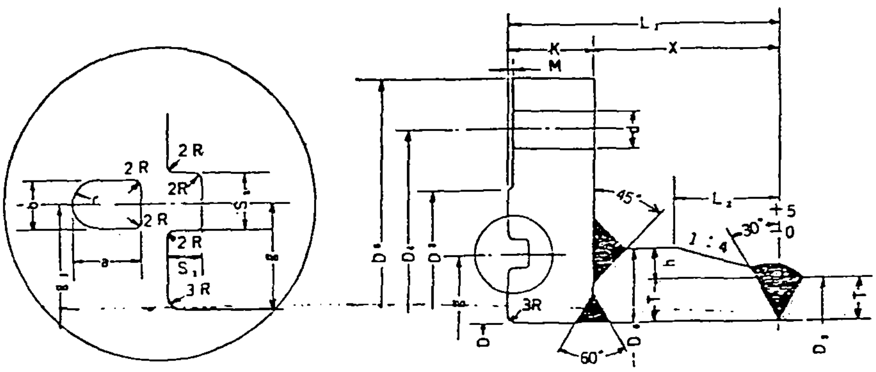

Figure 3. Special flange joint

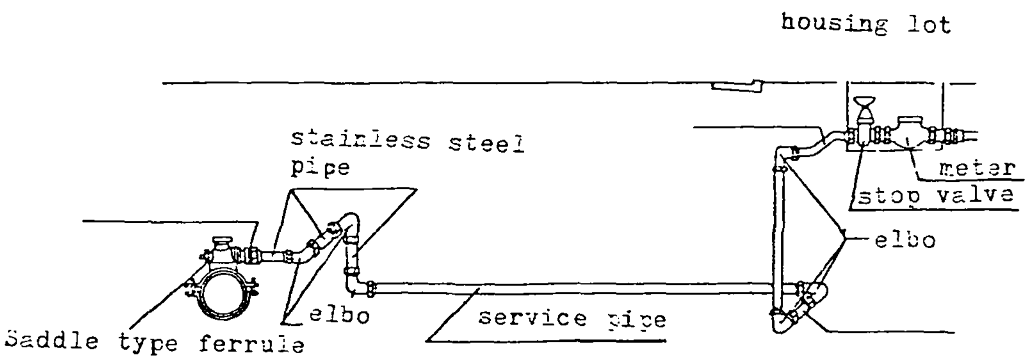

Figure 4. An example of stainless steel service pipe laying

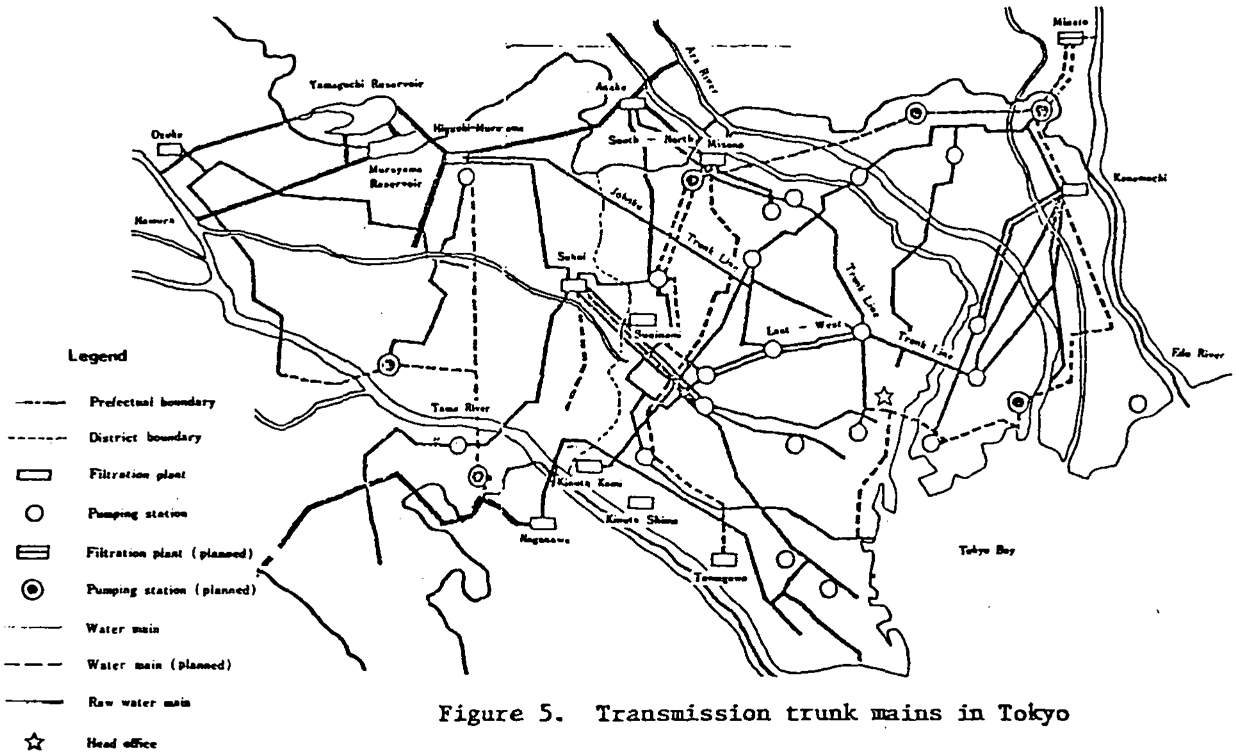

Figure 5. Transmission trunk mains in Tokyo

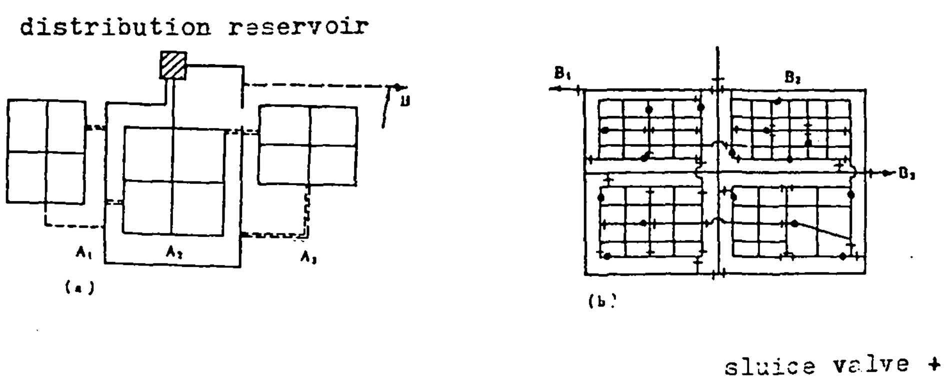

Figure 6. An example of block system

COMPRESSION MECHANISM OF ALUM SLUDGE UNDER CONSTANT PRESSURE

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1. INTRODUCTION

Water treatment plant sludges are generally known to consist of mixtures of soil, microorganisms, organics, and aluminium hydroxide. As alum sludge has high water content and high compressibility, it is extremely difficult to dewater.

In general, results of dewatering of alum sludges under constant pressure is applied to the Ruth's filtration formula. But, the phenomena occured in the cake have not been discussed before.

In this paper, the water content distributions in the cake under constant pressure dewatering were measured by slicing the cake to each thin layer, and compression characteristics of alum sludge were discussed according to the results of the compression-permeability test. Furthermore, compression mechanism of alum sludge was discussed by applying the consolidation theory by Shirato.[1] In this theory, the variable which indicates the position from the medium is defined by the solids mass deposited upon the medium per unit area.

2. MATERIALS

The alum sludge used in this study was obtained from water treatment plant at Natori City which used the Abukuma River as its raw water source. This alum sludge was discharged from chemical precipitation basins and backwash water of rapid sand filters. A sampling was conducted October, 1978.

The alum sludge was concentrated by gravity thickening and was also centrifuged at a speed of 2100 rpm (RCF 550) for 5, 10, 20, 40, minutes, respectively. The chemical and physical characteristics of the alum sludge are shown in Table 1.

Table 1 – Chemical and physical characteristics of alum sludge

chemical composition	physical characteristics
SiO_2 =51.4 %	ρ_s=2.38 g/cm^3
Al_2O_3 =19.7 %	Liquid Limit=340 % (n=0.89)
Ig.loss=15.0 %	Plastic Limit=110 % (n=0.72)

3. COMPRESSION-PERMEABILITY TEST

Compression-permeability test was conducted to investigate the characteristics of a compressive cake, and its apparatus is shown in Fig. 1. This apparatus makes it possible to make a uniform compressive cake against each applied loading, and make a permeability test of the uniform cake. Both single and double drainage can be allowed with valve operations.

The inside diameter of cylinder was 6 cm, and filter paper was used as a medium. The initial thickness of a sample was set to 3 cm by a dial gauge with the accuracy of 0.01 mm.

The sample of each initial water content w_0' (95.53%, 92.11%, 88.61%) was poured into the cylinder and the franges of the cap and the cylinder were fixed. The surplus of the sample was drained out from the valve (4) in order to avoid the pressure charge on the sample. The glass tube for the permeability test was set above the cap.

The applied pressure was added to the sample from the bottom and the displacement of the piston was read by a dial gauge.

The permeability test was conducted after the sample had been in equilibrium state against each applied loading stage.

The pressure of each drainage surface of the sample during the compression period was recorded by pressure transducers (Max 5 Kg-f/cm^2) and a recorder.

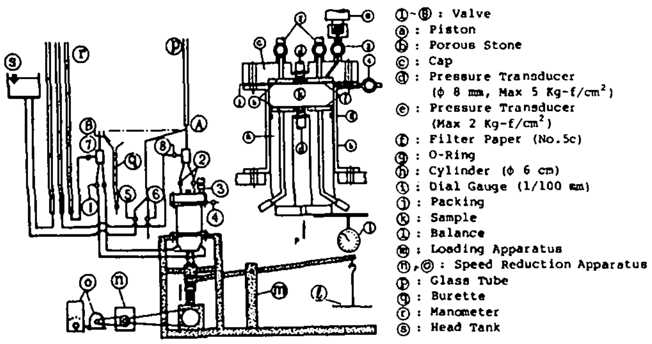

Fig. 1 Compression-Permeability Test Apparatus

4. CONSTANT PRESSURE DEWATERING TEST

The dewatering of a single drainage under constant pressure was conducted with the compression apparatus shown in Fig. 1. The drainage was permitted only from the bottom of the sample. The initial thickness of a sample was 2 cm and filter paper was used as a medium. The hydraulic pressure on impermeable face was measured by a transducer (Max 2 Kg-f/cm^2) and a recorder. The experimental conditions are shown in Table 2.

The dewatering tests were conducted until the hydraulic pressure on impermeable face became almost equal to zero, and were stopped at the time when each arbitrary filtrate was obtained. After the dewatering tests for each dewatering time, every cake was cut into slices having 0.5 mm thickness up to 3 mm from the medium and having 1 mm thickness more than 3 mm from the medium with the reading of the dial gauge.

All sliced cake layers were offered to determine the water content distributions within the cake.

Table 2 Experimental conditions and results under constant pressure compression

Exp. No.	w_0' (%)	P (g-f/cm^2)	L_1 (cm)	L_2 (cm)	$\frac{(L_0-L_1)}{(L_0-L_2)}$ (-)	K (×10^{-3}) (cm^2/sec)	C_e (×10^{-5}) (g^2/cm^4·sec)
A-1	95.67	713	0.740	0.233	0.713	1.02	0.382
A-2	94.05	758	0.800	0.318	0.713	1.06	0.762
A-3	92.41	742	0.873	0.415	0.711	0.839	1.15
A-4	90.97	741	0.929	0.482	0.706	0.783	1.34
B-1	95.65	1368	0.596	0.205	0.781	1.26	0.587
B-2	94.10	1405	0.688	0.265	0.756	1.20	0.829
B-3	92.36	1408	0.785	0.345	0.734	0.825	1.10
B-4	91.00	1397	0.829	0.396	0.730	0.657	1.32
C-1	95.60	2077	0.579	0.187	0.777	1.54	0.595
C-2	94.12	2073	0.636	0.240	0.773	1.16	0.994
C-3	92.30	2073	0.716	0.316	0.762	0.994	1.32
C-4	91.00	2077	0.772	0.356	0.747	0.773	1.16
C-5	88.65	2073	0.893	0.470	0.724	0.555	1.89

5. ANALYSIS

5 – 1 Filtration Process

In the case of constant pressure filtration, the reduction of sample thickness is equal to the filtrate per unit drain area, $(L_o - L)$. On the assumption that average specific resistance, a, and ratio of wet cake mass to dry cake mass, m, are constant, the following Ruth's equations are obtained.

$$(L_0 - L) + L_m = i\,[\,K\,(\theta_f + \theta_m)\,]^{1/2} \tag{1}$$

$$K = \frac{2g_c\,P\,(1 - ms)}{\mu\,\rho\,s\,\alpha} \tag{2}$$

5 – 2 Consolidation Process

During the consolidation period, solid particles in the cake are moved toward the medium with the reduction of porosity and the cake thick- is decreasing gradually.

Therefore, in this study the consolidation theory expressed by Shirato was applied. In this theory, the variable which indicates the position from the medium is defined by the solid mass deposited upon the medium per unit drain area. On the assumption that modified coefficient of consolidation, C_e, is constant, the basic formula of consolidation is expressed as Eq. (3).

$$\frac{\partial e_w}{\partial \theta_c} = C_e \cdot \frac{\partial^2 e_w}{\partial w_x^2} \tag{3}$$

The relationship between modified coefficient of consolidation, C_e, and coefficient of consolidation, C_v, defined by Terzaghi is expressed by Eq. (4).

$$C_e = \frac{C_v\,\rho_s^2}{(1 + e_w)^2} \tag{4}$$

The C_V value is calculated from the results of compression-permeability test, that is, by use of the relationship among equilibrium void ratio, e, and coefficient of permeability, k_D, against each compressive pressure, P_s, according to Eq. (5).

$$C_v = \frac{k_D}{m_v\,\gamma} \tag{5}$$

Therefore, the C_e value is calculated from solid density, P_s, equilibrium void ratio, e_w, and coefficient of consolidation, C_v, according to Eq. (4).

On the other hand, Eq. (3) is rewritten as Eq. (6) by use of Eq. (7).

$$\frac{\partial \phi}{\partial \tau_c} = \frac{\partial^2 \phi}{\partial \omega^2} \tag{6}$$

$$\phi = \frac{e_w - e_2}{e_1\,(w_0/i) - e_2},\quad \omega = \frac{i\,w_x}{w_c},\quad \tau_c = \frac{i^2\,C_e\,\theta_c}{w_c^2} \tag{7}$$

Initial condition and boundary conditions are expressed as Eq. (8).

$$\begin{aligned} \text{I.C.} &: \phi = \phi_1(\omega), \text{ at } \tau_c = 0 \\ \text{B.C.} &: \phi = 0 \quad , \text{ at } \tau_c = \infty \\ &\quad \phi = 0 \quad , \text{ at } \omega = 0, 2 \end{aligned} \tag{8}$$

If 0–W distribution in the cake at the initial state of consolidation period is expressed as 0_1 (w) = sin (tw/2), approximately, the 0–W distribution and average consolidation ratio, U_c, during consolidation period are expressed as Eq. (9) and Eq. (10), respectively.

$$\phi = \sin\left(\frac{\pi\omega}{2}\right) \exp\left(-\frac{\pi^2 \tau_c}{4}\right) \tag{9}$$

$$U_c = 1 - \exp\left(-\frac{\pi^2 \tau_c}{4}\right)$$

On the other hand, the C_e value is detetmined by use of the fitting method shown in Fig. 2.

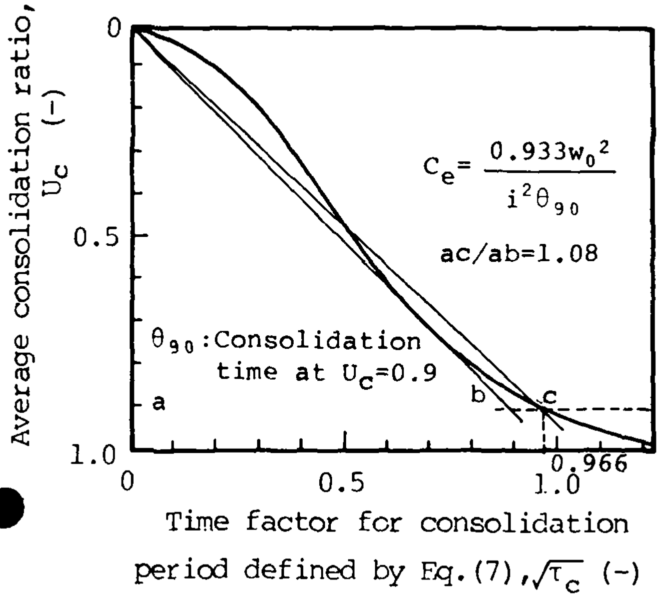

Fig. 2 U_c vs. $\sqrt{\tau_c}$

6. RESULTS AND DISCUSSION

6 – 1 Characteristics of Compressive Cake

Fig. 3 shows the relationship between compressive pressure, P_S, and equilibrium porosity, n, in the compression-permeability test. The relationship between Ps and n against each initial water content of alum sludge were expressed by the following experimental equation in the compressive pressure range of mor than 300 g-f/cm^2.

$$n = a \cdot \log_{10} P_s + b$$

Although the n value of equilibrium state against each compressive pressure slightly decreased with reduction of the initial water content of alum sludge, the difference among them was small.

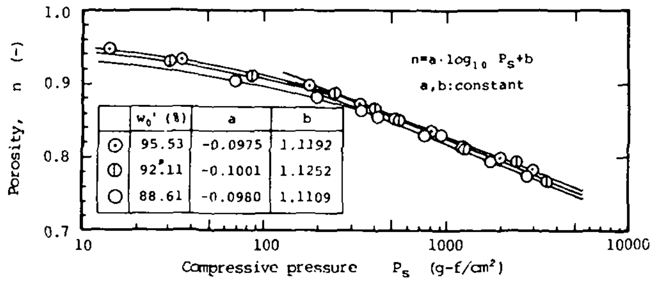

Fig. 3 n vs. P_s

The n value (at P_s = 300 g-f/cm^2) had from 0.88 to 0.90 and this value was almost equal to the n value of liquid limit (n = 0.89) presented in Table 1.

6 – 2 Modified Coefficient of Consolidation, C_e

Fig. 4 shows the relationship between modified coefficient of consolidation, C_e, and average compressive pressure, P_s. Alum sludge of each initial water content had about constant C_e values against P_s. The C_e value increased with the reduction of initial water content, but not increased with the increase of average compressive pressure.

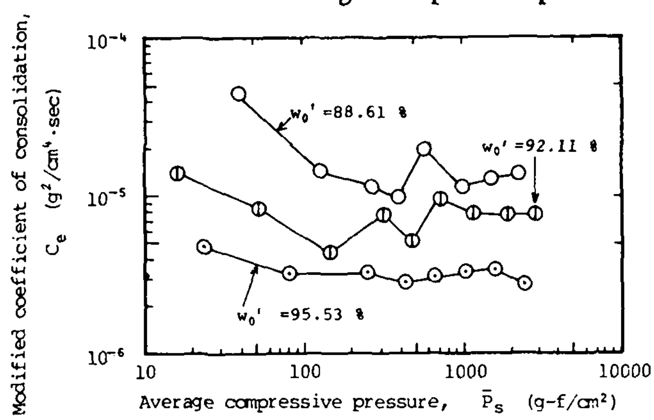

Fig. 4 C_e vs. $\bar{P}_s$

From these results, it was found that the reduction of initial water content of alum sludge was favorable for consolidation process and that the rate of consolidation was not improved with the increase of the applied pressure.

The results described above suggested that the consolidation process of the alum sludge could be analyzed by use of the consolidation theory expressed as Eq. (1).

6 – 3 Compression Mechanism under Constant Pressure

In filtration period, a linear relationship between the filtrate per unit area, $(L_o - L)$, and filtration time, $\sqrt{\Theta_f}$, existed. These results which satisfied Eq. (2) showed the parabolic relation between $(L_o - L)$ and Θ_f.

The transition point was defined as the point at the last time when the linear relation between $(L_o - L)$ and $\sqrt{\Theta_f}$ existed. The equilibrium point was defined as the point at the time when the hydraulic pressure on impermeable face became almost equal to zero. The transition point indicates the boundary between filtration period and consolidation period. Table 2 also shows the thickness of the transition point and the equilibrium point, L_1, L_2, respectively, and the ratio of the filtrate, (Lo – L1) / (Lo – L_2). The ratio of the filtrate had the range from 0.71 to 0.78. The lower the initial water content of alum sludge and the applied pressure were, the smaller were the values of ratio of filtrate.

The hydraulic pressure on impermeable face, P_x, was equal to the applied pressure, P, before the transition point, and started to drop at the slightly earlier time of the transition point and gradually approached to zero after the transition point.

Fig. 5-a shows the water content distribution within the cake under constant pressure dewatering, and Fig. 5-b shows the changes of the water content of the thin layers against each filtrate per unit area, (L_o – L). From Fig. 5-b, the changes of the water content of each layer indicated the S curve against the filtrate, (L_o – L), and the inflection point of the S curve of the 0 – 0.5 mm layer almost coincided with the transition point.

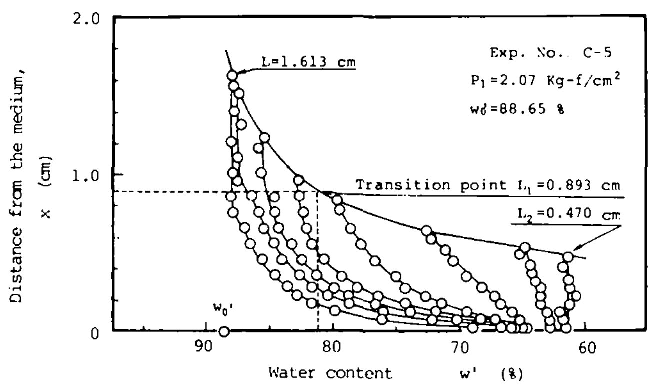

Fig.5-a x vs. w'

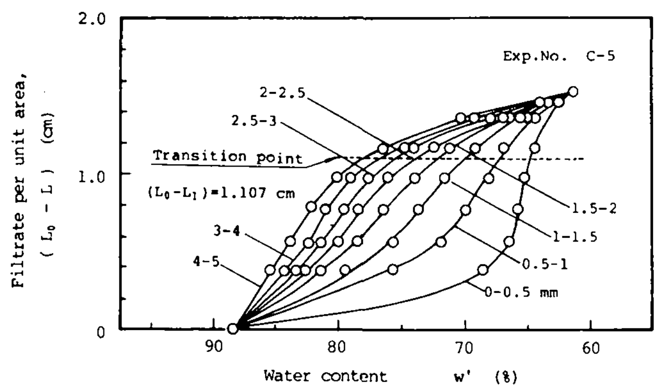

Fig.5-b (L_0 - L) vs. w'

Fig. 6 shows the reductions of water content from the initial water content of the first layer (0 – 0.5 mm layer) and of the second layer (0.5 – 1.0 mm layer) under the constnat pressure dewatering. Although the reduction of water content of the second layer made a great difference with the changes of the initial water content, that of the first layer made a little difference and could be expressed as a curve of its own applied pressure.

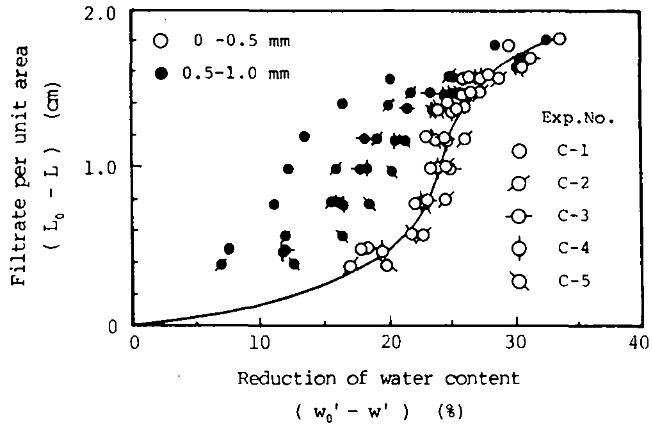

Fig. 6 (L_0 - L) vs. (w_0 - w')

The initial condition of consolidation period was determined as follows: at the transition point, the water content of each layer (0 – 5 mm layer) near the medium against the filtrate, (L_o – L_1), was determined from Fig. 5-b, and that of each layer near the impermeable face against the thickness of the cake, L_1, was determined from Fig. 5-a.

The distribution of the water content at the transition point determined above was transformed into the O-w distribution according to the Eq. (7), and then the e_2 value was determined from the results of the compression-permeability test shown in Fig. 3. The results were shown in Fig. 7-a. The O-w distributions at the transition point were approximated by the sine curve (O_1 (w) = sin (Tw/2).

Fig. 7-b shows the distribution of the hydraulic pressure (P_x/P vs. w) at the transition point from the results of the compression-permeability test and the following equation (12).

$$P_x = P - P_s$$

Shirato shows that at the transition point, the distribution of the hydraulic pressure of the material having middle compressibility can be approximated by the sin curve shown in Fig. 7-b.

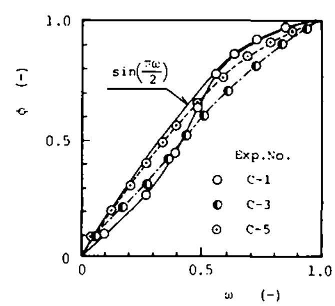

Fig.7-a ϕ - ω distribution (at transition point)

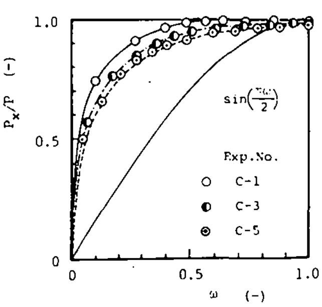

Fig.7-b Distribution of hydraulic pressure (at transition point)

But the hydraulic pressure distributions of alum sludge at the transition point were not approximated by the sin curve, because the percentage of the hydraulic pressure loss of the first layer (0 – 0.5 mm layer) occupied from 48% to 74% of the applied pressure. Here, the percentage of the thickness of this thin layer to that of the total layer at the transition point was from 5.4% to 8.6%.

From these results, it was found that the higher initial water content and applied pressure were, the larger was the difference of water content between the first layer and the second layer, and that the reduction of water content of the thin cake layer near the medium was the rate-limiting step of flow rate of the filtrate because of a high compressibility of alum sludge.

The C_e values of the alum sludge were determined by use of the fitting method shown in Fig. 2. The results are shown in Table 2. The C_e values increased with the decrease of the initial water content, but only slightly with the increase of the applied pressure. The C_e values shown in Table 2 were almost equal to the C_e values shown in Fig. 4.

From these results, it was also found that the decrease of the initial water content of alum sludge was favorable for the consolidation process and that the rate of consolidation was not improved with the increase of the applied pressure.

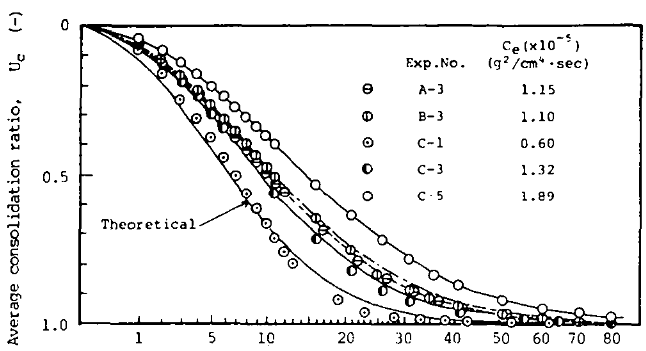

Fig. 8 U_c vs. $\sqrt{\theta_c}$
(after transition point)

Fig. 8 shows the experimental data ($(L_1 - L) / (L_1 - L_2)$ vs. $/O_c$) and the theoretical curve in the consolidation period after the transition point. These theoretical curves were calculated from the C_e values shown in Table 2 and from Eq. (10). The experimental data were approximated by the theoretical curve.

Strictly speaking, during the compression under constant pressure, the C_e value is a function of the position in the cake and time, and is not constant. If a precise agreement between experimental data and theoretical curve is desired, the variance of the C_e value in the cake must be considered.

7. CONCLUSION

A summary of the results of constant pressure compression in this paper is shown below:

(1) As alum sludge has high compressibility, the higher initial water content and the applied pressure, the larger is the difference of water content of cake layer near the medium. It seems that this thin layer is the rate-limiting step of flow rate of the filtrate.

(2) It is found that the value of the filtrate ratio has the range from 0.71 to 0.78, and the lower the initial water content of alum sludge and the applied pressure, the smaller is this value.

(3) The relationship between the filtrate per unit drain area and the reduction of water content of the thin cake layer (0 – 0.5 mm layer from the medium) shows the S curve and the inflection point of this S curve almost coincides with the transition point.

(4) The Θ-w distributions of transition point are approximated by the sin curve (O_1 (w) = sin (Tw/2)). But the hydraulic pressure distributions at transition point are not approximated by the sin curve, because the percentage of the hydraulic pressure loss of the thin cake layer (0 – 0.5 mm layer from the medium) occupies from 48% to 74% of the applied pressure. Here, the percentage of the thickness of this layer to that of total cake layer at the transition point is from 5.4% to 8.6%.

(5) The consolidation period after transition point can be expressed by the Shirato's consolidation theory, approximately. The values of modified coefficient of consolidation, C_e, increase with the decrease of the initial water content, but hardly increase with the increase of the applied pressure.

NOTATION

a,b : constants defined by Eq.(11)
C_e : modefied coefficient of consolidation ($g^2/cm^4 \cdot sec$)
C_v : coefficient of consolidation (cm^2/sec)
e : e = n/(1 – n), void ratio (-)
e_w : local void ratio at the position w_x (-)
$e_1(w_0/i)$: local void ratio at the position $w = w_0/i$ (-)
e_2 : final void ratio (-)
g_c : conversion factor (dyne/g-f)
i : number of drainage surface
K : Ruth's filtration coefficient (cm^2/sec)
k_D : coefficient of permeability (cm/sec)
L : thickness of sample (cm)
L_m : fictitious sample thickness equivalent to medium resistance (cm)
L_0 : initial thickness of sample (cm)
L_1 : thickness of sample at the transition point (cm)
L_2 : final thickness of sample (cm)
m : ratio of wet to dry cake mass (-)
m_v : $-(de_w/dP_s) / (1+e_w)$, coefficient of volume change (cm^2/g-f)
n : porosity (-)
P : applied pressure (g-f/cm^2)
P_s : cake compressive pressure (g-f/cm^2)
P_x : hydraulic pressure (g-f/cm^2)
s : s = 1-w'/100, mass fraction of solids in slurry (-)
U_c : average consolidation ratio (-)

W_s : mass of solids (g)

W_w : mass of liquid (g)

w_x : mass of cake solids per unit area in distance x from the medium (g/cm^2)

w_0 : total solids mass in original material per unit sectional area (g/cm^2)

w' : $w' = 100\ W_w/(W_s+W_w)$, water content (%)

w_0' : initial water content (%)

x : distance from the medium (cm)

GREEK LETTERS

α : average specific resistance (cm/g)

γ : liquid weight per unit volume ($g\text{-}f/cm^3$)

θ_c : time for consolidation period (sec)

θ_f : time for filtration period (sec)

θ_m : fictitious filtration time accounting for medium resistance (sec)

θ_{90} : time when $U_c = 0.9$ (sec)

μ : viscosity ($g/cm \cdot sec$)

ρ : density of liquid (g/cm^3)

ρ_s : true density of solids (g/cm^3)

T_c : time factor for consolidation period defined by Eq.(7) (-)

Φ : local consolidation ratio defined by Eq.(7) (-)

$\Phi_1(\omega)$: initial Φ-ω distribution for consolidation period

ω : distance factor for consolidation period defined by Eq.(7) (-)

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CHEMICAL CONDITIONING, THICKENING AND DEWATERING OF POLY ALUM CHLORIDE SLUDGE

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S. F. SHU

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The service area of the Taipei Water Supply System includes Taipei City and its four satellite townships of Sanchung, Hsintien, Yungho, and Chungho. The development and operation of the System is in the charge of the Taipei Water Department. To meet the rapid increase of demand for water in the service area, the Taipei Water Department is planning to construct a new water treatment plant which will consist of five units each of a capacity of 500,000 m^3/day. The new treatment plant, to be known as the Chig-Tan Water Treatment Plant, is now being designed and construction of the first unit is scheduled for completion before July 1984. The design criteria of various kinds of treatment process have been well developed over the past years. However, in order to avoid too conservative an approach, which will result in the waste of money, and to obtain a precise comparison of the efficiency of different types of clarification and filtration facilities, a pilot plant installed with static clarifier, tube settler clarifier, pulsator clarifier and single course media and dual media filter column was set up and operated from July 1980 through January 1981. In this pilot plant test, apart from comparing the efficiency and developing the design criteria of different types of clarifiers and filter media, sludge from the clarifiers was also tested for reference of sludge treatment design. The main objective of this paper is to describe and discuss the sludge treatment test.

Literatures

In order to provide a basis for the sludge treatment study, an extensive review of available literatures was undertaken. The most comprehensive investigation review relating to the problem of water treatment wastes disposal was published by the American Water Works Association Research Foundation(1). This study reports on many of the currently utilized methods of dewatering and disposal of various water treatment wastes. Table 1 lists the specific type of alum sludge process that has been studied and indicates the reference source of the process. According to the results of the pilot plant study, the best coagulant is poly alum chloride (PAC) and not alum. For the first unit of the treatment plant, because the sludge capacity is not very large and the sludge characteristics of this treatment have not been fully understood, mechanical dewatering will not be considered. A lagoon, or a drying bed, will be built for temporary use before the second unit is constructed. Thus, the temporary sludge treatment process will be sludge conditioning, thickening, and drying on the sand bed or disposal in the lagoon. The PAC sludge obtained from clarifiers of the pilot plant was tested to derive an understanding of the chemical conditioning, thickening, and dewatering characteristics.

Table 1: Sludge Processing Methods

Process	Reference No.
Gravity thickening	1, 2, 3
Sand drying beds	3, 4, 5
Polyelectrolyte conditioning	1, 6, 7

Material and Apparatus

(1) PAC Sludge Samples: Collected from the pilot plant's pulsator clarifier.

(2) Chemical Compounds for Sludge Conditioning: Polyelectrolyte provided by Batz, Calgon, Nalco and Lime.

(3) Sludge Thickening Equipment: 1 liter cylinder with scale.

(4) Solid-Liquid Separation Apparatus: Buchner Funnel with Whatman No. 2 Filters as shown on Fig. 1. This equipment is used to select the best polyelectrolyte and to judge the dewatering character of the sludge. Under a 38mm Hg vacuum pressure, the time required to filter 100ml of filtrate is considered to be proportional to the specific resistance of the sludge[8]. The shorter the time is, the better the dewatering characteristics will be.

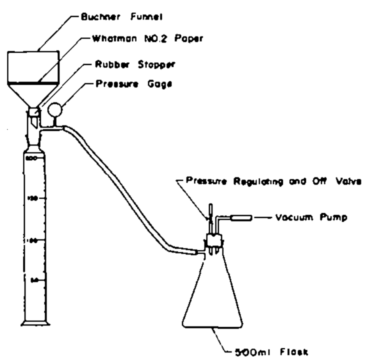

FIG.1 BUCHNER FUNNEL APRARATUS

(5) Sludge Drying Bed: Five acrylic tubes with a diameter of 15 centimers and of the height of 1 meter were used as shown on Fig. 2. Twenty-five 1-cm drainage holes were provided at the bottom of each cylinder. The filter media consisted of a 2-cm layer of fine pebbles with a 0.3-0.5 cm diameter range and on top of the pebbles was an 8-cm layer of sand with an effective size of 0.7 mm and a uniform coefficient of 1.9[9].

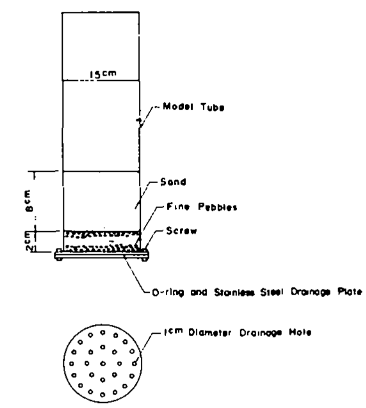

FIG.2 CROSS SECTION OF THE SLUDGE DRYING BED

Result and Discussion

1. *Characteristics of PAC Sludge*

During the course of the pilot plant test, the raw water has a very low turbidity (generally below 10 NTU) and is free from the problems of color or odor. The COD is below 3 mg/l. Therefore, the main components of the sludge samples are coagulant and suspended solid. Because the content of organic substance is very low, no odor will occur even if it is stored for a considerably long period of time. During the course of the pilot plant test, sludge retention time in the pulsator sludge concentrator is usually over 24 hours. Thus, after this preliminary thickening, sludge is quite high in concentration. Concentration of various sludge samples is shown in Table 2. The average concentration can be as high as 10,000 mg/l.

Table 2

Solid Concentration of PAC Sludge from Pilot Pulsator Clarifier

Date	1981					Average
	1/10	1/12	1/28	2/17	2/20	
Sludge Solid Conc. mg/l	9271	10537	10531	10006	11970	10452

Since in practical operation in the future sludge concentration may undergo a considerable degree of variation, sludge samples have been diluted to different concentrations to observe their thickening characteristics, and the results are shown in Fig. 3. From Fig. 3, it is known that the lower the concentration of sludge is, the better its thickening characteristics will be. If the concentration exceeds 6,000 mg/l, the speed of thickening is very slow and the efficiency will also be quite low. Moreover, no matter what the concentration of sludge is, after 24 hours of thickening, the concentration of sludge may reach 11,000 mg/l – 14,000 mg/l. Thus, if the clarifier is normally operated, the sludge will thicken considerably and preliminarily inside the concentrator and solid concentration of the discharged sludge will exceed 6,000 mg/l. If further thickening is required, chemical conditioning will be necessary to produce a conspicuous effect.

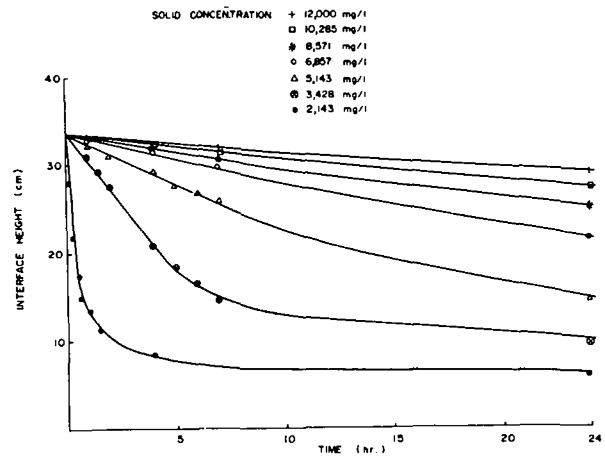

FIG. 3 THICKENING OF PAC SLUDGE WITH DIFFERENT SOLID CONCENTRATION

2. *Chemical Conditioning for Sludge Thickening*

There are many kinds of polyelectrolyte. After a preliminary selection, 19 kinds of polyelectrolyte, as shown in Table 3, were selected as the conditioners. Thereafter, the Buchner Funnel Test was adopted to determine the suitable polyelectrolyte. Results of the test are shown in Table

3. From this table, it is known that the conditioning efficiency of Ca-2300, Bz-1100 and Bz-1150 are better than that of the other chemicals.

Table 3

Sludge Conditioning Characteristics of Different Kinds of Polyelectrolytes

Polyelectrolyte	(2) WT 2640	(2) WT-2700	(2) WT-2900	(2) Ca-233	(2) Ca-243	(2) Ca-2300	(3) M-590	(4) Bz-1100	(4) Bz-1130	(4) Bz-1140
Time required to filter 100 ml filtrate, sec.	107	120	122	78	82	70	89	72	89	80
Polyelectrolyte	(4) Bz-1150	(4) Bz-1160	(4) Bz-1260	(4) Bz-1360	250P	(5) Nalco – 8174	607	623	677	
Time required to filter 100 ml filtrate, sec.	67	77	77	77	92	141	168	128	108	

(1) Polyelectrolyte dosage = 10 mg/1.
(2) Polyelectrolyte made by Calgon.
(3) Polyelectrolyte made by a local company.
(4) Polyelectrolyte made by Batz.
(5) Polyelectrolyte made by Nalco.

Both single-stage thickening and two-stage thickening are adopted for the following test and they have been individually conditioned with different chemical conditioners.

2.1 *Single-Stage Thickening*

For this test, polyelectrolyte, lime and polyelectrolyte-lime are individually used as the chemical conditioners. Fig. 4 shows the thickening efficiency when Ca-2300, Bz-1100, Bz-1150 and lime are used as the conditioners. From Fig. 4 it is known that the efficiency of Bz-1150 is better than that of Ca-2300, Bz-1150, and lime. However, the dosage of polyelectrolyte of Bz-1150 should be strictly controlled, because both insufficient dosage and overdosage will result in a poor thickening efficiency. Fig. 4 also shows that when the dosage of Bz-1150 is 0.8% of the sludge dry solid weight, it is almost impossible to thicken the sludge. This is because an overdosage will form very large and strong sludge flocs and the bounding water within the flocs will not be able to be squeezed out. Moreover, sludge will not be able to thicken due to the restraining effect among the flocs. Because the conditioning efficiency of Bz-1150 is better than that of the two other kinds and in order to simplify the test, the following tests were conducted using only Bz-1150 as the conditioner.

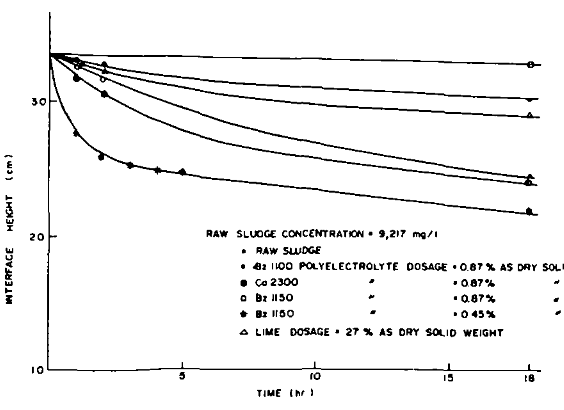

FIG. 4 SLUDGE THICKENING WITH DIFFERENT KINDS OF CHEMICAL CONDITIONER

If polyelectrolyte-lime is used as the conditioners, the results of the test are as shown in Fig. 5 and Fig. 6. From these two figures it is learned that when the dosage of lime is 28% of the sludge dry solid weight, the optimum dosage of polyelectrolyte would be 0.57 – 0.76%. And when the dosage of polyelectrolyte is 0.6%, the optimum dosage of lime would be 19 – 28.5%.

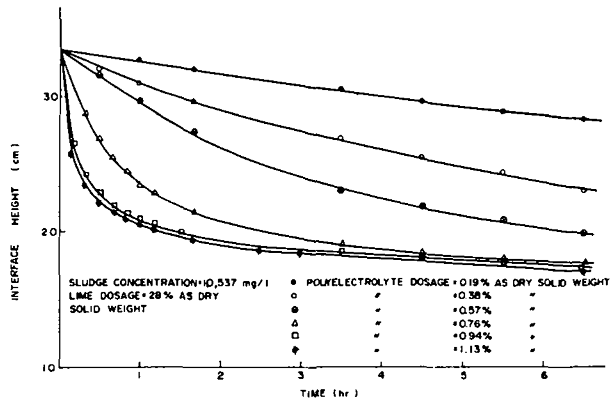

FIG.5 SLUDGE THICKENING WITH POLYELECTROLYTE AND LIME AS CONDITIONER

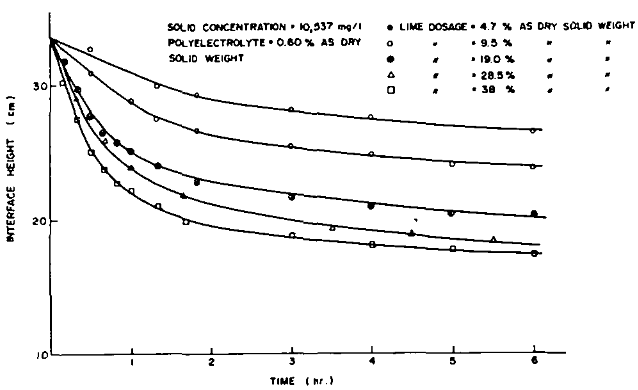

FIG. 6 SLUDGE THICKENING WITH POLYELECTROLYTE AND LIME AS CONDITIONER

2.2 *Two-Stage Thickening*

For this test, two methods of conditioning are tried. With the first method, no chemical is used for the first-stage thickening, and lime is used as the conditioner in the second stage. The results are shown in Fig. 7 and the figure shows that the efficiency of thickening is quite poor. Even when the dosage of lime reaches 35% of the sludge dry solid weight, after 24 hours of thickening the sludge can only reach a concentration of 22,000 mg/1 (not including the weight of lime).

With the second method, polyelectrolyte is used as the conditioner in the first stage and lime as the conditioner in the second stage. The results of the test are shown in Fig. 8 and Fig. 9. From these figures it is learned that in the first stage the dosage of polyelectrolyte should be strictly controlled at below or equal to 0.41% of the sludge dry solid weight and in the second stage, the optimum dosage of lime is about 15 – 25% of the sludge dry solid weight and the pH value is about 12.

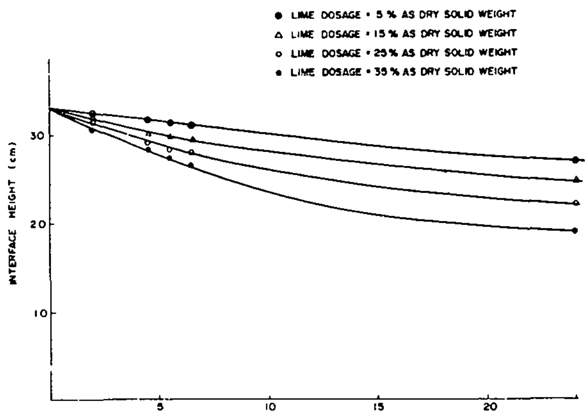

FIG. 7 SLUDGE THICKENING WITH LIME AS CONDITIONER IN THE SECOND STAGE OF A TWO-STAGE THICKENING TEST

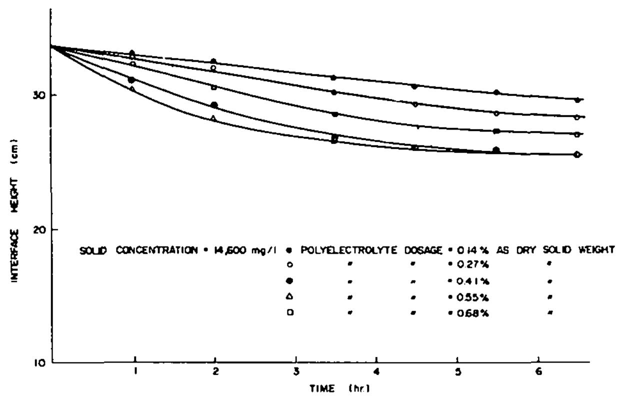

FIG. 8 SLUDGE THICKENING WITH POLYELECTROLYTE AS CONDITIONER IN THE FIRST STAGE OF A TWO-STAGE THICKENING TEST

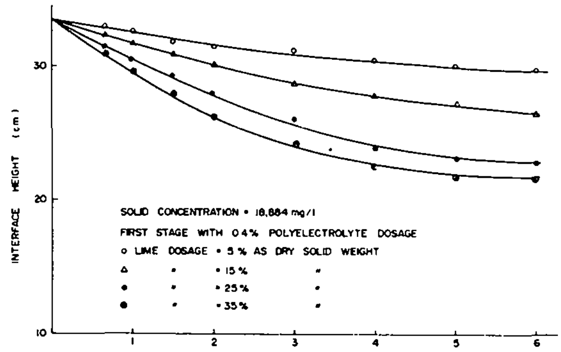

FIG. 9 SLUDGE THICKENING WITH LIME AS CONDITIONER IN THE SECOND STAGE OF A TWO-STAGE THICKENING TEST

2.3 *Design Criteria of Sludge Thickener*

From the above-mentioned tests it is known that for chemical conditioning of the single-stage thickening, a better result is achieved when a polyelectrolyte dosage of 0.6% of the sludge dry solid weight and a lime dosage of 20% of the sludge dry solid weight are used as the conditioner. For chemical conditioning of the two-stage thickening, a better result is achieved when 0.4% of polyelectrolyte is used in the first stage and 20% of lime is used in the second stage.

Based on the test results and the following formula[10] the required area of the sludge thickener may be calculated as follows:

$$A = \frac{Q_o\, tu}{Ho}$$

where A = the area required for sludge thickener (m^2)

Q_o = flowrate into the thickener (m^3/min.)

H_o = initial height of interface in column (m)

t_u = time to reach the desired thickened sludge concentration (min.)

From Fig. 10 and 11, the required t_u value may be obtained.

From Fig. 10 it is known that t_u = 200 min. and the thickened sludge concentration = 25,000 mg/1. Thus, the area of the single-stage thickener is:

$$A = \frac{200\ Qo}{0.335} = 597\ Qo.$$

From Fig. 11 it is known that t_{u1} = 230 min. Thus, the area of the first stage thickener is:

$$A_1 = \frac{230\ Qo}{0.335} = 687\ Qo,$$

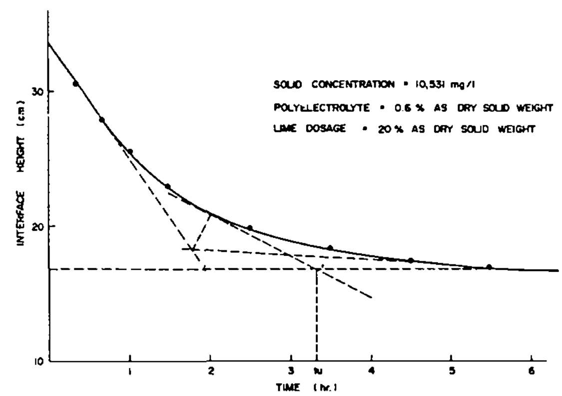

FIG. 10 Tu VALUE OF SINGL STAGE SLUDGE THICKENER

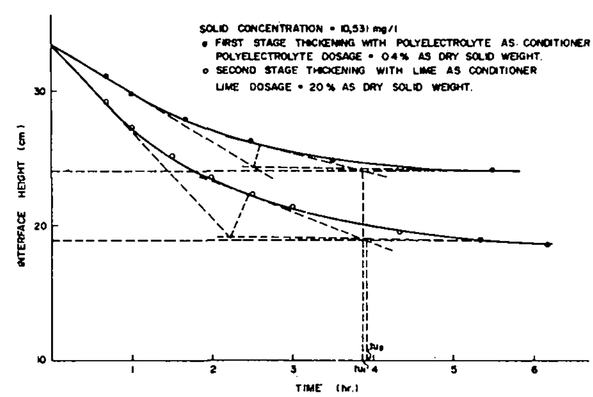

FIG. 11 Tu VALUE OF TWO STAGE SLUDGE THICKENER

and the volume of the thickened sludge is about 72% of the raw sludge. Thus, $Q_1 = 0.72\,Qo$, $tu_2 = 231$ min., and the thickened sludge concentration = 31,000 mg/1. Thus, the area of the second stage thickener is:

$$A_2 = \frac{231\,Q_1}{0.335} = \frac{231 \times 0.72 Qo}{0.335} = 496\,Qo.$$

2.4 *Comparison of Single-Stage and Two-Stage Thickening*

(1) The surface area required for single-stage thickening = 597 Q_o; the surface area required for two-stage thickening = (687 + 496) Q_o = 1183 Q_o. Thus, in terms of capital cost, single-stage thickening is less expensive than two-stage thickening.

(2) The polyelectrolyte required for two-stage thickening is less than that for single-stage thickening by about 0.2% of the dry solid weight. Thus, in terms of chemical cost, two-stage thickening is less expensive than single-stage thickening.

(3) With regard to thickening efficiency, two-stage thickening is better than single-stage thickening.

(4) With regard to operational flexibility, two-stage thickening is better than single-stage thickening.

Although the capital cost of single-stage thickening is lower than that of two-stage thickening, the thickening efficiency is lower, more chemicals are required and operational flexibility is also lower. Also, the operational efficiency of sludge thickening in both Japan and France indicates that two-stage thickening is much better[11]. Thus, two-stage thickening is recommended for adoption.

3. *Chemical Conditioning for Sludge Dewatering*

After thickening of sludge, irrespective of the adoption of mechanical dewatering or a sand drying bed, effective dewatering can only be achieved after conditioning. In order to examine the efficiency of conditioning thickened sludge with different types of chemicals, such as polyelectrolyte, lime as well as polyelectrolyte-lime were used and the Buchner Funnel test was conducted to detect the dewatering characteristics of thickened sludge. The results of the test are shown in Fig. 12. From this figure, it is learned that if only polyelectrolyte is used as the conditioner, the optimum dosage is 0.17% of the sludge dry solid weight. If only lime is used as the conditioner, the optimum dosage is 22% of the sludge dry solid weight and the pH value is 13.2. If the dosage of lime is fixed at 13% of the sludge dry solid weight and the pH value is 13.0, the optimum dosage of polyelectrolyte is 0.13% of the sludge dry solid weight. The operational cost of the three different types of conditioners are shown in Table 4. From this table it is known that if only polyelectrolyte is used as the conditioner, the chemical cost would be the lowest at about US$7.76/ton of dry solid, but its conditioning effect would be poorer. If only lime is used as the conditioner, or if lime-polyelectrolyte is used as the conditioner, there is not much difference in the efficiency of conditioning, their chemical costs, at US$38.61 and US$34.79/ton of dry solid respectively, are not much different. If only polyelectrolyte is used as the conditioner, the chemical cost is about five times lower than those for the two other kinds of conditioners, and since its dosage is small it will not increase the quantity of the sludge. However, observation reveals that when sludge is conditioned with polyelectrolyte its bounding water cannot be easily squeezed out, and during the Buchner Funnel test, the vacuum break condition occurs only after quite a long period of time. With regard to sludge conditioned with lime or lime-polyelectrolyte, only 1 – 1.5 minute is required for the vacuum break to occur in the Buchner Funnel. From the above comparisons of the operational cost and the dewatering efficiency of various types of conditioners, a definite decision cannot be made as to which type of conditioner is more suitable for sludge dewatering. Therefore, there is the need for the conduct of a dewatering pilot test. A decision can be reached only after a comparison of the required costs of dewatering equipment, chemicals, energy and the clearing and transporting of sludge cakes.

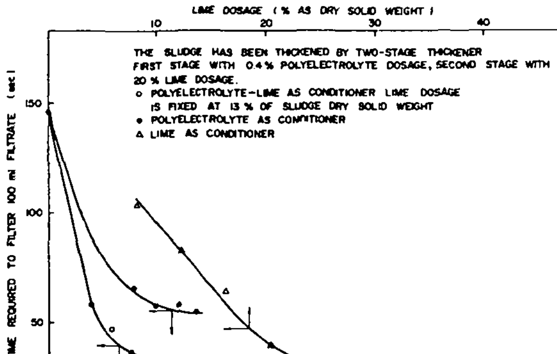

FIG. 12 SLUDGE CONDITIONING WITH DIFFERENT KINDS OF CHEMICAL CONDITIONER

Table 4
Comparison of Optimum Dosage, Chemical Cost, and Dewatering Characteristics of Different Kinds of Conditioners

Item	Use Polyelectrolyte as sludge conditioner			Use lime as sludge conditioner			Use lime-polyelectrolyte as sludge conditioner, lime dosage is fixed at 13%		
	Optimum dosage %	Time required to filter 100 ml filtrate sec.	Chemical Cost US$ Ton dry solid	Optimum dosage %	Time required to filter 100 ml filtrate Sec.	Chemical Cost US$ Ton dry solid	Optimum dosage %	Time required to filter 100 ml filtrate Sec.	Chemical Cost US$ Ton dry solid
Two-stage combine dosage thickening sludge	0.17	57	7.76	22	34	38.61	0.13	36	34.79

*Price of polyelectrolyte = 9.2 US dollars/kg
Price of lime = 0.16 US dollars/kg, purity = 90%

4. *Sludge Drying Bed Test*

The sludge adopted for this test is the two-stage, polyelectrolyte-lime thickened sludge which has been conditioned by polyelectrolyte-lime before being put into a sludge drying bed. The dosage of polyelectrolyte is 0.13% of the sludge dry solid weight, and the dosage of lime is 13% of the sludge dry solid weight. The solid loading of the drying bed is 15 kg/m^2, 20kg/m^2, 25kg/m^2 and 30kg/m^2 respectively and the sludge depth is 0.4 m, 0.53 m, 0.67 m and 0.8 m respectively.

4.1 *The Infiltration Rate of Sludge Drying Bed*

The infiltration rate of the drying bed was quite high. After 2 hours, the sludge began to shrink and 24 hours later, the surface of the sludge cracked. All the gravity water was drained, and the solid concentration reached 12-14%. The infiltration rate of the sludge drying bed is shown in Table 5.

Table 5
The Infiltration Rate of Sludge Drying Bed

Infiltrated water volume (1) / Infiltration time (hr.)	Solid loading (kg/m^2)			
	15	20	25	30
1	2.6	3.5	3.5	3.75
1.5	2.85	4.0	4.3	4.75
2	2.95	4.2	4.7	5.25
2.5	2.95	4.4	5.0	5.7
3	2.95	4.5	5.15	6.0
18	2.95	4.8	5.6	7.0
24	2.95	4.8	5.6	7.0

4.2 *Sludge Drying Time*

Table 6 indicates that the solid concentration of sludge cake will reach 20% after 20 days of drying at the condition of drying under a shed and the solid concentration of the sludge cake is not obviously influenced by changing the solid loading of the sludge drying bed. But considering the convenience of operation and of cleaning the drying bed, the depth of sludge should not be too deep. It is recommended herewith that the solid loading of the drying bed be set at about 20-25 kg/m^2, and the depth of the sludge be set at about 0.6 m. At the condition of drying without a shed, the solid concentration of the sludge cake also can reach 20% after 20 days of drying. Although there were 12 rainy days during the course of the test, the water content of the sludge cake had not increased. It indicates that the drying bed was not penetrated or clogged by sludge, and water can easily be drained through the cracks of the sludge cake. After the solid concentration of the sludge cake reached 20%, the increasing rate of solid concentration became very slow. Thus, it is known that the economical drying period of the sand drying bed is about 20 days. At such a period of time for drying, the cake solid concentration would be about 20%, and cakes can be cleared away manually or mechanically.

Table 6. Sludge Drying Test of Sand Drying Bed

Solid Conc. of sludge % / Drying time (day)	Solid loading of sludge drying bed,					Weather	Temp. C°
	With shed				Without shed		
	15	20	25	30	20		
1	13.7	13.5	13.3	12.9	13.9	Cloudy, occasional rain	15
2	14.3	13.4	13.6	12.9	14.9	"	13
3	15.5	13.9	14.4	13.5	15.2	"	8
4	–	–	–	–	–	"	15
5	16.1	15.9	15.1	15.0	17.3	Fair	18
6	–	–	–	–	–	Fair	20
7	16.7	16.9	16.1	15.2	17.6	Cloudy, occasional rain	18
8	–	–	–	–	–	Fair	22
9	17.1	16.8	17.0	16.0	17.8	Cloudy	20
10	–	–	–	–	–	Fair	23
11	17.5	17.0	17.6	17.0	17.9	Cloudy	18
12	–	–	–	–	–	Cloudy, occasional rain	18
13	–	–	–	–	–	Fair	23
14	19.0	17.5	17.7	17.0	18.5	Cloudy, occasional rain	18
15	–	–	–	–	–	Cloudy	20
16	19.9	19.1	19.1	18.7	19.3	Fair	22
17	–	–	–	–	–	Fair	22
18	21.2	19.7	19.8	19.6	19.8	Fair	22
19	–	–	–	–	–	Rain	22
20	–	–	–	–	–	Cloudy	19
21	21.4	20.1	20.3	20.0	20.9	Rain	18
22	–	–	–	–	–	Rain	22
23	–	–	–	–	–	Rain	20
24	22.8	20.9	20.9	21.0	22.2	Rain	21

5. *Conclusion and Suggestion*

(1) Two-stage sludge thickening using a dosage of polyelectrolyte-lime is the best way for PAC sludge thickening. First first-stage thickening using polyelectrolyte as the conditioner, the optimum dosage is about 0.4% of the sludge dry solid weight, and the dosage should be strictly controlled to avoid overdosage. With regard to the second-stage thickening using lime as the conditioner, the optimum dosage is about 20-25% of the sludge dry solid weight. After two-stage thickening, the solid concentration of sludge will increase from 10,000 mg/1 to 31,000 mg/1.

(2) The required area for the first-stage sludge thickener = 687 Q_o, and for the second-stage sludge thickener, the area required = 496 Q_o
where Q_o = Raw sludge flowrate, m^3/m

(3) Lime or polyelectrolyte-lime is suitable for conditioning thickened sludge to improve the sludge dewatering characteristic. If lime is used for sludge conditioning, the optimum dosage will be 20-25% of the sludge dry solid weight. If polyelectrolyte-lime are used for sludge conditioning, when the dosage of lime is fixed at 13% of the sludge dry solid weight, the optimum polyelectrolyte dosage will be 0.13% of the sludge dry solid weight. If only polyelectrolyte is used as the conditioner, its optimum dosage is 0.17% of the sludge dry solid weight and its chemical cost is lower and it will not increase the solid loading. However, its efficiency of conditioning is poorer and a dewatering pilot test must be conducted to determine whether it can be used as the conditioner for dewatering. Due to the limitations of

time and fund, no such test was conducted for the purpose of preparing this paper.

(4) The infiltration rate of the sludge drying bed, with conditioned sludge, is quite high and after 24 hours all the gravity water will be drained out, and the solid concentration of the sludge cake will reach 12-14%.

(5) The solid concentration of sludge is not obviously influenced by changing the solid loading of the drying bed. After 20 days of drying, irrespective of the fact whether drying is carried out under or not under a shed, the solid concentration of sludge will reach 20%.

(6) It is herewith recommended that the solid loading of the drying bed be set at 20-25 kg/m^2, the sludge depth be set at 0.6 m, and the drying time be set at 3-4 weeks.

Future Work

The sludge drying bed or lagoon is only a temporary treatment process for the first unit of the Chih-Tan Water Treatment Plant. Due to the limited space available for use as the drying bed and the lagoon and due to the large labor requirement, sludge will be dewatered by mechanical process when the second unit is added. Thus, after the first unit is completed, a mechanical dewatering pilot test must be conducted to provide reference for designing a mechanical dewatering process. Furthermore, under the test reported in this paper it was discovered that if only polyelectrolyte is used as the conditioning chemical before dewatering, the conditioning efficiency would be inferior to that using only lime or lime-polyelectrolyte. However, the cost of the chemical would be lower and the process will not increase solid loading. Its suitability needs to be reviewed if a mechanical dewatering pilot test is carried out in the future.

Acknowledgment

This pilot plant test was conducted at the existing Hsintienchi Water Treatment Plant of the Taipei Water Department and was sponsored by the Taipei Water Department. Acknowledgment is also made to the Department for its financial and other support to the conduct of this test.

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MODERN SURFACE WATER FILTRATION TECHNIQUES APPLIED TO MANILA WATER

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France

1. Introduction

For many years, the techniques employed for the filtration of clarified or merely coagulated water on open filters remained unchanged. In addition, essential differences existed between fine sand and coarse sand filtration techniques.

Indeed, regulations in the United States set a standard maximum rate of 2 US gpm/sq. ft., i.e. 4.88 m3/hr/m2 for all installations providing drinking water. The initial publications by CONLEY dealing with results obtained using dual media filters profoundly modified former ideas, and for the last fifteen years or so it has become common to encounter filtration rates of 5 to 6 US gpm/sq. ft. (12.20 to 14.64 m/hr) and peaks of 8 gpm/sq. ft. (19.50 m/hr).

Parallelly, work in Europe showed that the filtration rate, tactily limited to 5 to 6 m/hr, could be increased to values generally between 10 and 15 m/hr by the use of deep bed filters. In certain cases, peaks of over 20 m/hr have been obtained.

It is interesting to analyze the evolution of these various techniques and their application during the tests we conducted on the water supplying the BALARA treatment plant in Manila.

PART I – FILTRATION TECHNIQUES

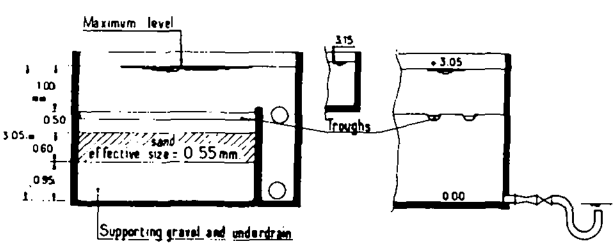
I. THE TRADITIONAL FILTER WITH A SINGLE LAYER OF FINE SAND (fig. 1)

1.1 *Characteristics of the traditional filter with sand alone, backwashed with water*

The traditional fine sand filter is characterized by:

- A filtering bed of sand with an effective grain size of 0.55 mm; approx. layer depth 0.60 m.
- A 1.50 to 1.80 m depth of water above the sand.
- A geometrict fall between the water level in the filter and the restitution level of approximately 3 meters, with clogging generally allowed up to 1.80 to 2.40 m.
- A mechanical flow controller, with or without auxiliary fluid, remote controlled or not. This controller is associated with a differential pressure flow measurement device (venturi, short venturi, etc.) placed on the filtered water outlet. This system maintains the flow treated constant, and at the same value in each filter. This value is adjusted manually or automatically as a function of the level downstream in the treated water reservoir or of the level in the clarified water channels.

TRADITIONAL FINE SAND TYPE FILTER (effective size 0.55mm.) Fig 1
Backwashed with water alone. Filtration rate 2 US gpm/sq. ft. i.e. 4.88m/hr



- Washing with water alone, by backwashing at a filtered water flow rate of at least 35 to 40 m/hr; this flow rate is adjusted as a function of the water's temperature and viscosity so as to obtain a predetermined degree of filter bed expansion. In addition to backwashing, the filter bed's surface is washed with pressure water by means of hydraulic sprinkles. Surface washing breaks up the "cake" that forms on the surface during the filtration cycle and prevents the formation of mud balls.

1.2 Limits and evolution of this traditional fine sand technique

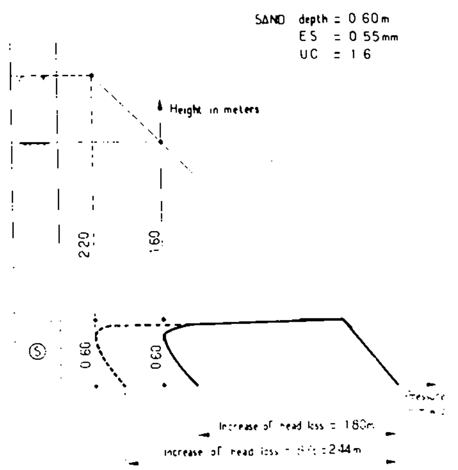
1.2.1 *Limits: surface clogging – limited filtration rates*

- Fine sand filters tend to clog very rapidly on the surface, especially when the water contains plancton or when a polyelectrolyte is used. Surface clogging is accentuated by washing with water alone which, due to filter bed expansion, causes hydraulic grading during which the finest sand grains (approx. 0.3 mm) are carried up to the surface.
- Analysis of the pressures in the filter bed at a filtration rate of 2 gpm/sq. ft., i.e. 4.88 m/hr (fig. 2), reveals that the bed loss due to clogging must be limited to 1.80 m to prevent negative pressure in the filtering layer with a water depth of 1.60 m above the sand bed.
- For the maximum increase in the head loss due to clogging commonly scheduled (8 feet – 2.44 m), a water depth of 2.20 m would be necessary above the sand to prevent any negative pressure: such water depths are generally not employed.

fig 2

TRADITIONAL FINE SAND FILTER

V = 4.88 m/hr = 2 US gpm/sqft



- This type of filter is unsuitable for high rate filtration due to surface clogging, which results in usually very short filter runs.

This is even more true if such filters are used to treat water with a high algae content, which increases surface clogging: filter runs are very short in such cases and water losses due to washing are quite high. If the clarified water's quality suddenly drops for any reason, all the filters become clogged simultaneously and filter operation is no longer possible. Reduction of the plant's output is the only solution.

To obtain in-depth clogging of the filtering bed and to increase the filtration rate, American techniques employ dual media and multi-media filters.

I.2.2. *Evolution: the multi-media filter* (fig. 3 and 4)

The use of anthracite (lighter than sand and having a larger grain size) on top of a layer of fine sand or, in certain cases, of a third layer of even finer and heavier material (garnet) placed below the sand permits:

- In-depth clogging of the anthracite, which retains impurities throughout its entire depth.
- Retention of impurities which pass through the anthracite layer on the layer of fine sand or finer material.
- Washing with water at the same flowrate per m2 as with fine sand alone, i.e. 30 to 45 m/hr, depending on the size of the materials employed and on maximum temperature of water.

The minimum effective size of the anthracite is 0.8 mm, and the usual size is between 0.9 and 1 mm. The effective size of the sand is generally between 0.45 and 0.55 mm, but can be as much as 0.65 mm in certain cases.

fig 3

DUAL MEDIA FILTER (Sand-Anthracite)

Filtration rate = 12.20 m/hr = 5US gpm/sqft

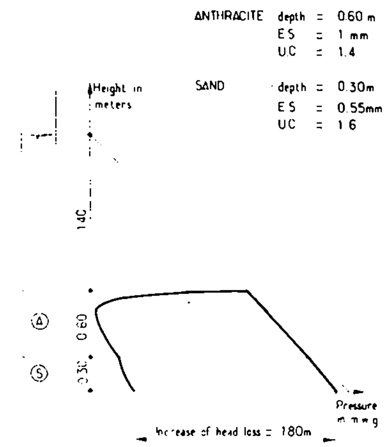
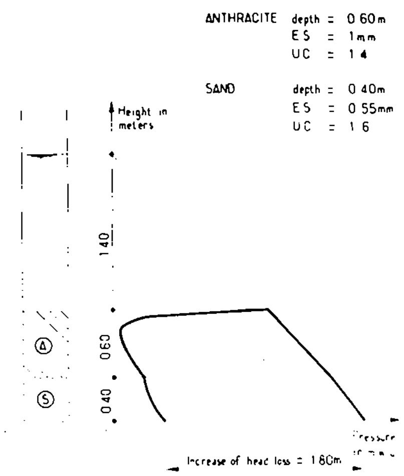


fig 4

DUAL MEDIA FILTER (Sand-Anthracite)

Filtration rate = 14.64 m/hr = 6US gpm/sqft



These characteristics result in the following:

- The possibility of considerably increasing the filtration rates, generally between 10 and 15 m/hr for drinking water treatment and more for the peak flows or less refined treatments.
- An increase in the water volume filtered per m2 of filter area, and a reduction in the percentage of water lost, even though a slightly larger volume of wash water is required per m2 of filter area than with 0.55 mm sand alone.
- A better quality clarified water.

Nevertheless,

(a) Washing of these multi-media filters with water alone still causes grading of each of the filtering layers by grain size: although these layers are homogeneous when placed in the filter, this is no longer true after washing. The fines of the largest grain size layer (usually the anthracite) collect on the surface after washing due to hydraulic grading, and they continue to create partial surface clogging: the more friable and heterogeneous the anthracite, the more this phenomenon occurs. Correct application of this technique thus requires use of very high quality anthracite with minimum friability and as low a uniformity coefficient as possible (1.5 max.). The cost of this material is thus high, especially since the number of suppliers disposing of good quality anthracite is limited the world over.

(b) Anthracite loss due to washing is around 5% per year, or more if operation is not well conducted (often 7%).

(c) This washing procedure requires adjustment of the flowrate as a function of the water temperature in order to obtain proper bed expansion. Washing must thus be properly adjusted all year long and requires use of a regulator and flow measurement device.

Depending on the importance of the backwash water rate, the sand and anthracite layers are either perfectly separated or partially mixed. It has been proven beneficial to tolerate mixed media as far as the quality of the filtered water and the duration of filter runs are concerned. Mixed media require a lower backwash water flowrate and are thus more economical.

(d) Mud balls, which with the older technique only formed on the surface, have a tendency to form in-depth with multi-media filters. In dual media filters, there is a marked tendency for mud ball formation on the surface of the anthracite and at the separation point between the sand and the anthracite. To destroy such mud balls, use was originally made of two surface washers, placed at the two levels of primary formation.

However, this dual washer system is no longer suitable for two reasons: use of polyelectrolytes makes the precipitates retained "stick" throughout the entire filtering mass, and there is no clear separation between the sand and anthracite in the mixed media technique.

At present, the washer system is advantageously replaced by scouring with air alone prior to washing with water. This return flow of air, which is traditionally employed in European filtration techniques, significantly improves mud ball elimination in dual media filters.

(e) Finally, examination of the head loss curves (fig. 3 and 4) for a dual media filter operating at 5 and 6 gpm/sq. ft., i.e. 12.20 and 14.64 m/hr, with a water temperature close to 26°C, shows that:

- A water depth of 1.40 m minimum is required above anthracite to avoid negative pressure in the filter bed at 12.20 and 14.64 m/hr filtration rates. This figure applies to respective total filtering layer depths of 0.90 m and 1 m, effective grain sizes of 1 mm (anthracite) and 0.55 mm (sand), and a head loss increase due to clogging of 1.80 m (approx. 6 feet).
- This water depth of 1.40 m minimum must be increased to 1.65 m for a total filtering bed depth limited to 0.75 m.

In conclusion, the advent of the multi-media filter has radically transformed the possibilities of single-layer fine sand filters washed with water alone. This type of filter permits the use of high filtration rates while producing a better quality filtered water.

Of course, these new filtration possibilities involve higher costs for the filtering materials (in particular for anthracite) and require much more attention for limitation of anthracite loss and for washing adjustment.

II. EUROPEAN FILTERS AND THEIR EVOLUTION — AQUAZUR FILTERS

II.1. Characteristics of the traditional filter — AQUAZUR T with homogeneous coarse sand

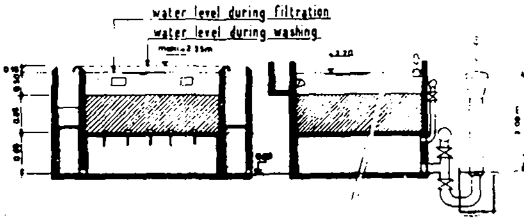
The traditional Euorpean filter, and more specifically the DEGREMONY AQUAZUR T filter, was long characterized by:

- An 0.85 to 1 meter deep filtering bed of homogeneous round grain sand with an effective size between 0.9 and 1 mm.
- A shallow depth of water above the sand during filtration (approx. 0.50 m)
- A geometric fall limited to approx. 2 m for a filtration rate of 5 to 6 m/hr.
- Equal distribution of the flow at the filter inlets. Without any manual intervention, each filter receives an inflow equal to the general flow divided by the number of filters in service. This equal distribution is obtained by a system of orifice plates inserted in the admission check valves, and by a same constant level maintained on all filters.

TRADITIONAL HOMOGENEOUS SAND FILTER (Effective size 0.95mm) Fig 5
WITH SHALLOW WATER DEPTH

(Washed simultaneously with water and scour air)

FILTRATION RATE 5m/hr AQUAZUR T FILTER



- Regulation of the water level on the filters by a siphon placed on the filtered water outlet. This regulation system discharges a filtered water flow equal to the inflow until such time as maximum clogging occurs, without flow measurement.
- Simultaneous backwashing with filtered water and scour air, followed by rinsing with water alone. Washing takes place *without expansion* of the filtering medium by raising the water level up to the level of the wash water evacuation weirs. This type of washing requires a filtered water backwash flow of 6 m3/m2/hr during air scour and 20 m3/m2/hr during rinsing, instead of the 35 to 40 m3/m2/hr required for fine sand filters washed with water alone.

Basic principles of the traditional AQUAZUR filter

- The effective size of the sand used (0.95 mm) is larger than that utilized for traditional fine sand filters washed by water alone (0.55 mm), but is about the same as that of the anthracite used in dual media filters. This allows the same quality filtered water to be obtained, this quality being mainly due to the chemical employed.
- A filtering bed with a homogeneous grain size is employed, and the bed *remains homogeneous* even after washing, i.e. the effective size of the sand on the surface is equal, after washing, to that in lower part of bed. This is in contrast to what occurs in 0.55 mm fine sand filters, where washing with water alone causes hydraulic grading of the sand from top to bottom, such that the sand on the surface has an effective size of any 0.30 to 0.40 mm.
- The AQUAZUR filter washing system combines water and air simultaneously, without causing expansion of the filter bed; this prevents hydraulic grading and maintains the homogenity of the filtering bed. In addition, simultaneous washing with water and air prevents mud ball formation.
- Equal distribution of the flow at the filter inlet obviates the need for individual flow measurement for each filter. In addition, a regulation system maintains the level in the filters constant. This system does not require staff intervention when the plant flow changes. Clogging is measured by a simple vacuometer.
- This type of filter only requires a low geometric fall (generally about 2 m) between the inlet and outlet of the filter.
- Finally, washing is carried out when the vacuum at the top of the siphon reaches 1.50 m, corresponding to an increase in the head loss of approx. 1.10 m in the sand. As seen from the curve of the pressures in the filter bed (fig. 6), there is no negative pressure in the bed at this head loss value, which is equivalent to a head loss increase due to clogging of 8 feet in a 0.55 mm effective size sand filter.

In conclusion, this technique, adapted to a maximum filtration rate of 7 or 8 m/hr, is of remarkable simplicity, and eliminates most of the difficulties encountered with the single layer fine sand filter washed by water alone. However, it is not compatible with high filtration rates.

It is interesting to discuss the evolution of this technique which has allowed the high filtration rates employed today.

II.2. **Adaptation of this technique to high rate filtration AQUAZUR V filter** (fig. 7)

To permit filtration rates of 10 to 20 m/hr, we have developed the technique of filtration on a single layer of homogeneous sand washed by air and water simultaneously in the AQUAZUR V filter.

In comparison with the AQUAZUR T filter, the depths of sand and water above the sand are increased according to the filtration rate. The AQUAZUR V filter is based on the same basic principles as the T model: in-depth filtration on a bed of homogeneous sand which remains homogeneous after washing thanks to a washing system employing air and water followed by rinsing without expansion of the filter bed.

(a) *Filtration*

A sand depth of 1.30 to 1.50 m is sufficient to permit filtration rates of 5 to 6 gpm/sq. ft., i.e. 12.2 to 15 m/hr.

T TYPE AQUAZUR FILTER. pressures at a filtration rate of 5 m/hr Fig 6

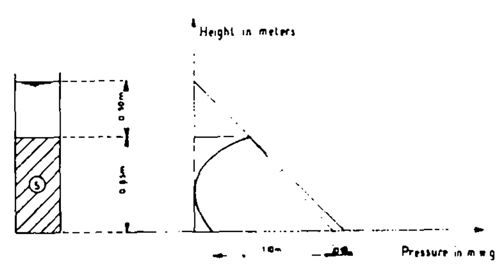


Fig 7

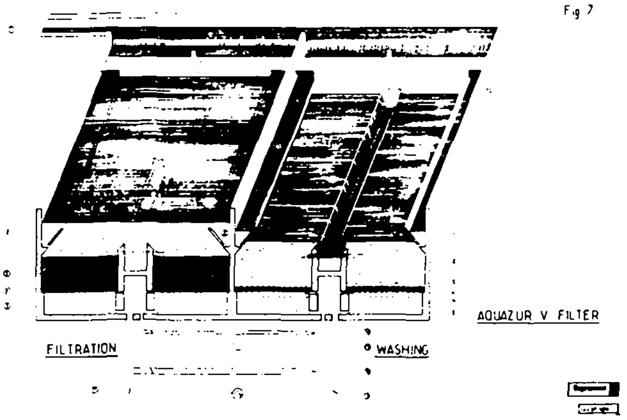


Fig 8

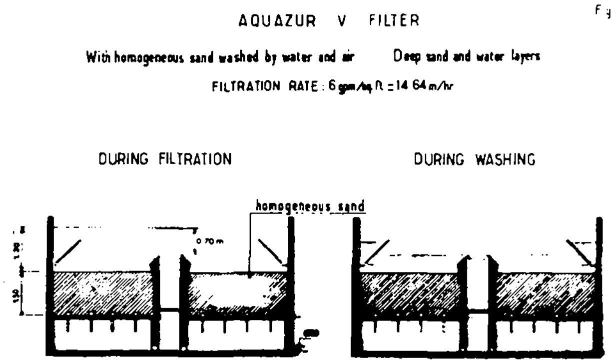


Fig 9

V TYPE AQUAZUR FILTER. Pressures at a filtration rate of 14.64 m/hr

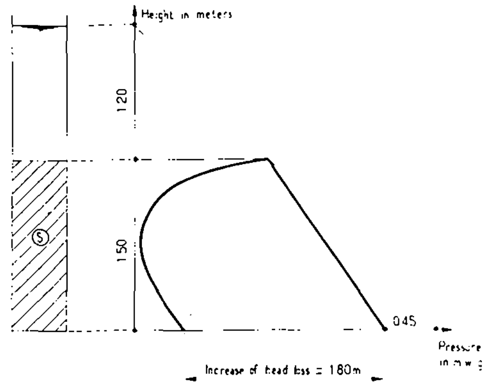


Figure 8 represents an AQUAZUR V filter adapted for a filtration rate of 6 gpm/sq. ft., i.e. 14.64 m/hr:

- 1.20 m water depth over the sand
- 1.50 m of homogeneous sand (average effective size 0.95 mm)
- 0.05 m gravel layer, covering the head of the nozzles.

This filter normally operates with a head loss limit due to clogging of 1.80 m without causing any negative pressure in the sand bed, as shown by fig. 9.

(b) *Washing without expansion and with surface cross-wash*

Once the maximum clogging limit has been reached, the water level is lowered to the level of the wash water weirs by filtering or by draining out the upper 0.70 m of water. Washing is then carried out with scour air and filtered water together at a backwash rate of 15 m3/m2/hr of filtered water. During this time, part of the clarified water flow continues to enter the filter and is employed to quickly push the impurities to the weir (cross-wash).

II.3. Comparison of an AQUAZUR V filter and a dual media filter

(a) *Technical considerations*

Both types of filter can produce filtered water meeting the requirements of consulting engineers and international tender specifications in the range of filtration rates employed, i.e. up to 15 m/hr or more. The standard is generally a maximum turbidity of 1 JU or even 0.5 JU in the most severe cases.

- The deep layer of sand increases the contact time in the filter bed: this aids flocculation in filters, direct coagulation in filters without prior settling, nutrification (in the case of iron removal treatments), and improves the quality of the filtered water, which is similar with both types of filter.
- Washing of the sand-only filter with water and air is more efficient and prevents mud ball formation; this is not the case with dual media filters washed with water alone and equipped with a surface washing device.
- No intervention is required on the level controller of an AQUAZUR filter when the flow changes.
- *Both types of filter have equally long filtration cycles.*

This important affirmation, which we have proven many times, can easily be understood by the formulas governing filtration and by results of tests.

Formulas governing filtration (fig. 10)

- o let t_1 be the time during which a filter produces clear water
- o let t_2 be the time required for a filter to reach the maximum head loss for which it is designed.

A well-designed filter treating well-conditioned coagulated or clarified water must have a clear water production time t_1 greater than or at least equal to t_2, corresponding to maximum clogging, in order to avoid filter breakthrough.

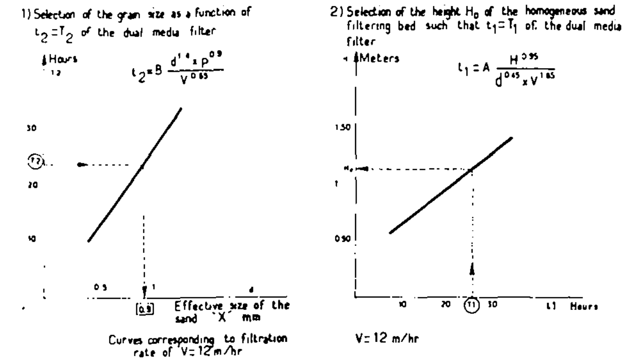
We have established the following formulas governing t_1 and t_2 for the filtration of clarified water with in-depth clogging of the media:

$$t_1 = A \frac{H^{0.95}}{D^{0.45} \times V^{1.85}}$$

$$t_2 = B \frac{D^{1.4} \times dP^{0.9}}{V^{0.65}}$$

FIG. 10

SINGLE LAYER HOMOGENEOUS SAND FILTER EQUIVALENT TO A SAND-ANTHRACITE FILTER



In the above formulas:

A and B	:	coefficients
D	:	effective size of the filtering media in mm
H	:	height of the filter bed in meters
dP	:	increase in the head loss in m W.G.
V	:	filtration rate in m/hr

These formulas are based on tests we conducted for filtration rates of 5 to 20 m/hr, and are only applicable for homogeneous sand filters which remain homogeneous after washing.

This explains why they differ from the formulas of BAYLIS, which were established for sand filters that do not remain homogeneous after washing with water alone.

Thus, BAYLIS found a time t_2 which is a function of $dP^{0.6}$ since the fines concentrate on the surface, whereas with a homogeneous sand filter with fines on the surface one obtains $dP^{0.9}$.

It is easy to design a single layer homogeneous sand filter with deep sand and water layers washed by water and air such that its filtration cycle t_2 is equal to that of a dual media filter (T_2) containing sand and anthracite for example.

- o If, at the rate under consideration (12 m/hr for ex.), filtration cycles are carried out with sands of different effective sizes in a single layer homogeneous sand filter with deep sand and water layers, a curve of t_2 as a function of D (the effective grain size) is obtained (fig. 10).
- o For the time T_2 in the dual media filter, the grain size to be selected for the single layer filter can be read off this curve. In the case of the curve used as an example, D = 0.90 mm. For this sand again size, the time t_2 of the single layer filter will thus be equal to that (T_2) of the dual media filter.
- o With the same filtration rates, if filtration cycles are then carried out with different heights H of sand having an effective size equal to that found previously (0.90 mm in this example), the curve obtained defines the time t_1 as a function of the height H during which the water produced complies with the requested guarantees.

The height H_0 of 0.90 mm sand corresponding to the time $t_1 = T_1$ of the dual media filter operating under the same conditions defines a homogeneous sand filter with deep sand and water layers, washed by water and air, equivalent to a dual media filter as concerns both the clear water production time and the time required to reach maximum admissible clogging.

A choice thus exists between two techniques; selection of one or the other must take into account both ease of operation and economic aspects.

(b) *Economic aspects*

- AQUAZUR V filter washing only requires a filtered water backwash flow of 15 m3/m2/hr, whereas the dual media filter requires almost three times this amount, and thus considerably increases the price of the washing equipment.
- Less water is consumed during washing of a single layer homogeneous sand filter than a multi-media filter.
- Since single layer homogeneous sand filters are washed with a constant flow of water, associated with a scour air flow, there is no need for an elevated water tower, a wash water flow controller or a flow measurement device. Provisions need only be made for a constant output pump drawing filtered water from the outlet channel or clear water reservoir and no adjustments are necessary.
- The cost of the sand-only filtering bed is much lower than that of the specially calibrated double bed of sand and anthracite.
- While little sand is lost with filters, anthracite loss from dual media filters is more important due both to attrition and low specific gravity which produces some entertainment to sewer during washing.
- Sand filter operation is much easier, and does not require special supervision, as needed for dual media filters to prevent anthracite losses.

Taking both investment and operating costs into account, the above factors reveal that the deep sand and water layer filter is more interesting than the dual media filter washed with water alone from both economic and practical viewpoints.

In conclusion, it is clear that two techniques can be used in high-rate filtration: the dual-media filters and the in-depth homogeneous single-media filters. With an appropriate design, they are theoretically equivalent as regards filtration run time and filtered water quality, the second type being nevertheless more attractive due to their lower cost and easier operation.

We shall continue this comparison by examining the practical aspects given by these two types of filter on a pilot plant.

PART II — APPLICATION OF FILTRATION TECHNIQUES TO THE WATER AT MANILA

I. GENERAL

Having been invited by the consulting engineer of the MWSS of Manila to conduct tests, if we so desired, to demonstrate the suitability of our processes and equipment, we installed a pilot station at the BALARA plant which supplies drinking water to Manila.

As shown on figure 11, this station consisted essentially of:

- a PULSATOR clarifier/flocculator, 590 mm diameter, with outside vacuum chamber and concentrator,
- a 300 mm diameter filter designed to operate either with dual media (sand/anthracite) or with a single layer of sand.

The clarification rates, indicated on the following tables, are calculated over the total area, minus the vacuum chamber area, of an industrial PULSATOR operating at the same rise rate on its sludge blanket as those applied in this pilot unit.

We shall only discuss here the results of high rate filtration.

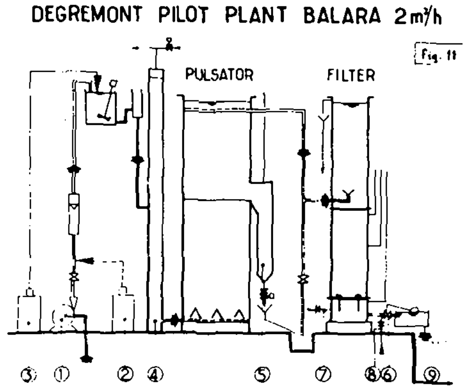
Since this pilot station only included a single filter, the various media were tested successively with different treatments.

I.1. Characteristics of the three filter types tested

(a) *Fine homogeneous sand*

Nominal effective size . .	0.56 mm
Uniformity coefficient . .	1.89
Bed depth	1.40 then 1.60 m

DEGREMONT PILOT PLANT BALARA 2m³/h



1 Raw water pump
2 Coagulant aid
3 Polymer
4 Vacuum chamber
5 Sluge concentrator
6 Filtered water outlet
7 Air inlet
8 Wash water inlet
9 Filtered tank for washing

This sand, not in current use in plants designed by Degremont, with a grain size similar to that used in conventional filters backwashed with water, gave short filter runs. Although very fine, the sand in the filter bed could be clogged in-depth under the combined action of backwashing and scour air.

This sand was employed for cycles 1 to 13, when the Pulsator was operated with:

- aluminum sulfate only, and with an anionic aid
- ferric chloride only
- NALCO 5 WP only (direct filtration)

(b) *Dual media*

Anthracite:

effective size	0.8 – 1.6 mm
uniformity coefficient . .	1.4
bed depth	0.60 mm

Sand:

effective size	0.55 mm
uniformity coefficient . .	1.6
bed depth	0.40 m

The water depth above the anthracite during filtration was 1.90 m. The dual media were used for cycles 15 to 25, when the Pulsator was operated:

- solely to provide a contact period, with coagulation being carried out directly on the filter and use made of only cationic polymers
- as a clarifier, with the jar test does of aluminum sulfate and a non-ionic polymer
- as a clarifier, with a low aluminum sulfate dose and a cationic polymer

Filter washing employed only scour air, followed by expansion with water alone at a rate of approx. 35 m/hr.

(c) *Medium size homogeneous sand*

Effective size	0.95 mm
Uniformity coefficient . .	1.65
Bed depth	1.60 m
Water depth over the sand during filtration . . .	1.30 m

This sand was employed for cycles 26 to 34, when the Pulsator was operated with:

- cationic polymers only, and highly turbid raw water,
- low doses of aluminium sulfate and cationic polymer.

The filter was washed with scour air (55 m/hr) and water (15 m/hr) followed by rinsing water only (15 m/hr).

I.2. **Characteristics of the raw feeding the pilot station and the BALARA plant** (table 12)

PH	7.2 to 7.7	Average 7.5
Color	5 to 50 Pt. Co Units	Average 18.5
Turbidity	2.2 to 185 JTU	Average 35

Typical analysis conducted on 6.11 1975:

Temperature	26°C approx.
TAC.	77 mg/1 as $CaCO_3$
TH	61 mg/1 as $CaCO_3$
TCa	60 mg/1 as $CaCO_3$
NH_4.	0.1 mg/1
Fe	0.1 mg/1
Mn	0.05 mg/1
SiO_2.	20 mg/1
C1	10 mg/1
Dissolved O_2	6.9 mg/1 at 26°C
Permanganate demand in an acid medium	1.95 mg/1 O_2

Figure 12

CHARACTERISTICS OF RAW WATER FEEDING THE DEGREMONT PILOT PLANT AND THE PLANT OF BALARA (MANILA)

pH	7.2 to 7.7	Average 7.5
Color	5 to 50 Pt. Co Units	Average 18.5
Turbidity	2.2 to 185 JTU	Average 35

TYPICAL ANALYSIS CONDUCTED ON 6.11.1975:

– pH	7.5
– Temperature	26°C
– Turbidity	5.5 JTU
– Suspended Solids	6.8 mg/1
– Color	20 Pt. Co Units
– T.A.C.	77 mg/1 as $CaCO_3$
– Total Hardness	61 mg/1 as $CaCO_3$
– Calcium	60 mg/1 as $CaCO_3$
– NH_4	0.1 mg/1
– Iron	0.1 mg/1
– Silica	20 mg/1
– Chlorides	10 mg/1 as Cl_2
– Dissolved O_2	6.9 mg/1
– Permanganate value in Acid Medium	1.95 mg/1

This water has a high temperature and is characterized by its low calcic bicarbonate mineralization. Pollution is very low and the turbidity is low three to four months every year, during which time direct coagulation is possible on filters. The peak turbidity recorded in 1974 was 185 JU. Finally, the plancton content is not very high despite the high temperature: the yearly average is 500 algae/ml.

I.3. **Test conditions and comparisons**

These tests were conducted at various filtration rates; the loss of head in the pilot filter was generally allowed to rise to 2.80 m (including the initial head loss in the sand and filter floor).

To permit comparison, we reduced the filter run durations to the times that would have been obtained with a *filtration rate of 14.64 m/hr* and a *head loss increase due to clogging of 1.80 m (6 feet),* which is a value commonly employed for industrial filters.

II. HOMOGENEOUS FINE SAND FILTER – RESULTS WITH LOW TURBIDITY RAW WATER (7 JU max.) (Table 13)

II.1. **Clarification with aluminium sulfate only**

(a) *With the jar test dose (40 g/m3)* (cycle 10)

– Cycle 10 reveals that a cycle duration of 24 hours was obtained: this is acceptable at a filtration rate of 14.64 m/hr.

Such filter runs are exceptional for fine sand filters; this result was due to the very good quality of the water clarified in the pilot PULSATOR (average 1.5 JU) and to the fact that, for this filter, we adopted the same washing technique as for AQUAZUR filters, which prevents collection of the fine sand grains on the surface after washing.

Fig 13

HOMOGENEOUS FINE SAND FILTER
With low turbidity raw water (7 JU Max)

Cycle N°	Coagulant dose g/m³	Polymer dose and type	Clarific. rate m/hr	Filtrat. rate m/hr	Run filter hours	Filtered volume m³/m²	Head loss increase m	TURBIDITY (JU) R.W Average	C.W Average	F.W Average	Results reduced to V=14.64 m/h with head loss increase of 1.80 m: Run filter hours	Filtered volume m³/m²	S S retained kg/m²
1) ALUMINIUM SULFATE													
10	40	0	3.92	14.85	29	430	2 20	5.5	1 5	0 15	24 4	358	0 60
8	15	0	3.86	13.50	15	203	1.60	5	3 8	0.55	15 8	232	0 94
2) FERRIC CHLORIDE													
11	25	0	4.96	17.70	16 5	292	2.18	5 2	1 6	0 17	15 6	228	0 41
12	35	0	4 36	17.70	24.5	434	2.10	6	0 8	0.10	24 1	353	0 31
3) ALUMINIUM SULFATE + ASP6 (ANIONIC POLYMER)													
5	40	0.08	3 86	14.64	24	382	2 04	5 3	1.5	0 10	21 5	314	0 55
9	40	0.10	3.86	13.5	16	216	2.08	5.4	1 2	0 15	13 5	198	0 26
7	15	0.02	3.86	13 5	18	203	1.96	5	2.8	0 30	16 2	237	0 74
4) CATIONIC ONLY (Nalco 5 WP = CATIONIC POLYMER)													
13	0	1	3.86	13.1	11.5	150	2.20	8 5	4.3	0 43	8 6	127	0.81

– The filtered water's turbidity is excellent (average 0.15 JU).

– Suspended solids retention is low (0.6 kg/m2) for a head loss increase due to clogging of 1.80 m.

(b) *With a low aluminum sulfate dose (15 g/m3)* (cycle 8)

The filter operated practically as though the clarifier did not exist, i.e. direct coagulation occurred.

The turbidity of the filtered water oscillated constantly between 0.5 and 0.65 JU (without filter breakthrough prior to maximym head loss) and the filter run was shorter than cycle 10, where the jar test aluminum sulfate dose was used. In cycle 8, the filter run was less than 16 hours at a filtration rate of 14.64 m/hr.

Suspended solids retention was not very high (0.94 kg/m2) for direct coagulation on a filter.

II.2. **Clarification with ferric chloride alone** (cycles 11 and 12)

The jar test dose of ferric chloride was close to 35 g/m3. We conducted two cycles: n° 11 with a 25 g/m3 dose, and n° 12 with the jar test dose.

As with aluminum sulfate, we obtained:

- a 24 hour run with the optimum jar test dose at a filtration rate of 14.84 m/hr (cycle 12)
- a 16 hour run (approx.) at a low dose (cycle II)

The better quality clarified water obtained with ferric chloride compensates for the fact that the residual floc passing on the filter has a high clogging capacity: this results in a lower SS retention power (0.31 to 0.41 kg/m2).

The filtered water's turbidity is always excellent (average 0.10 to 0.17 JU).

II.3. **Clarification using aluminum sulfate and a weakly anionic polymer** (PROSEDIM ASP 6 type)

(a) *With a jar test aluminum sulfate dose (40 g/m3)* (cycles 5 & 9)

Whereas cycle 10 gave a run over 24 hours without use of an aid, introduction of a weakly anionic polymer at a filtration rate of 14.64 m/hr caused the filter run to drop to:

o 21.5 hours with 0.05 ppm of polymer (cycle 5)
o 13.5 hours with 0.10 ppm of polymer (cycle 9)

This is easily explained by the fact that the water to be filtered has a higher clogging capacity.

This polymer improves the quality of the filtered water, but is unnecessary for this type of fine sand and a head loss limit due to clogging of 1.80 m. At most, use could be made of a lower dose (0.02 ppm to avoid inevitable filter breakthrough).

(b) *With a low aluminum sulfate dose (15 g/m3) and a low anionic polymer dose (0.02 ppm)* (cycle 7)

Cycle 7, in which an anionic polymer was used, can be compared with cycle 8, in which the same aluminum sulfate dose but no polymer was used:

o addition of a low anionic polymer dose (0.02 g/m3) produced a filtered water with an average turbidity of 0.30 JU; the turbidity always remained below 0.5 JU, which was not the case without a polymer
o at a filtration rate of 14.64 m/hr, the run duration is practically identical (approx. 16 hours) without a polymer or with a low dose

II.4. **Treatment with a cationic product only (NALCO 5 WP) Direct coagulation on a filter** (cycle 13)

With 1 ppm of NALCO 5 WP, no flocculation is obtained during clarification, and the clarifier only serves to provide a contact period: the filter is employed for direct coagulation.

A filtered water turbidity of just barely 0.5 JU is obtained at a filtration rate of 14.64 m/hr.

In contrast, the micro-floc has a very high clogging capacity and the filter run is too short (approx. 8.5 hours) to allow use of this treatment.

II.5. **General conclusions on tests with homogeneous fine sand washed like an AQUAZUR filter, using a low turbidity raw water (7 JU max.) and a filtration rate of 14.64 m/hr**

- The best treatment is clarification using aluminum sulfate alone or ferric chloride alone at the optimum jar test dose. The filter runs obtained are approximately 24 hours, which is long for this type of filter: this result is due to the filter washing system which maintains the filtering bed more or less homogeneous.
- Of the various treatments tested, the most economical is use of a low aluminum sulfate dose (15 g/m3) for clarification together with a low dose of an anionic polymer (close to 0.02 ppm/m3) for obtention of a satisfactory turbidity (below 0.5 JU) and to prevent any risk of filter breakthrough.
- Suspended solids retention is low in all cases (0.31 to 0.94 kg/m2).

III. DUAL MEDIA FILTER USED FOR DIRECT COAGULATION WITH CATIONIC POLYMERS ONLY

III.1. **With a low turbidity water (5 JU max.)** (table 14)

Various cationic polymers were tested.

(a) *Using the contact period provided by the PULSATOR*

The doses of the polymer NALCO 5 WP used were 1 g/m3 in cycle 14 and 0.6 g/m3 in cycles 15 and 15 bis.

At a filtration rate of 14.64 m/hr, the filter runs in all three cases were more or less acceptable (from 18 to 32 hours), but the filtered water's turbidity exceeded 0.5 JU on an average and rose at times to 1 JU. It would have been necessary to increase the cationic product does to lower the filtered water's turbidity, but this would have also considerably shortened the filter runs.

(b) *Without using the contact period provided by the PULSATOR*

The polymers employed were 572 C from American Cyanamid (average dose 0.5 g/m3) in cycle 16 and Betz 1190 (same average dose) in cycle 17.

The results were similar to those described above. At this dose, the filter runs are acceptable (28 to 32 hours), but the filtered water's average turbidity is 0.5 to 0.6 JU and a peak of 1 JU was recorded.

Here again, it would have been necessary to increase the polymer does to lower the filtered water turbidity, but this would have shortened the filter runs.

(c) *Conclusion*

This treatment does not always give satisfactory turbidities, but higher polymer doses than those used (0.5 to 1 g/m3) would result in excessively short filter runs.

AQUAZUR V SAND FILTER FOLLOWING CLARIFICATION OF AN ARTIFICIALLY TURBID WATER

Results reduced to [illegible] with head loss increase [illegible]

Cycle N°	A.S. dose	Polymer dose and type	Clarific rate m/hr	Filtrat. rate m/hr	Run filter hours	Filtered volume m^3/m^2	Head loss increase m	TURBIDITY (J.U.) R.W Average	C.W Average	F.W Average	Run filter hours	Filtered volume m^3/m^2	S.S. retained kg/m^2	NOTE
30	0	2.5 g/m3 Nalco 5WP	4.33	17.20	38	654	0.32	320 JU 1120 mg/l	2.5	0.40	42.2	618	1.62	max. F.W turbidity < 0.5 JU
					78	1342	2.10	320 JU 1120 mg/l	2.5	0.44	75.4	1104	2.84	max. F.W turbidity = 0.7 JU
31	180	0.3 g/m3 AS P6	3.26	12.20	128	1525	2.24	300 JU 910 mg/l	2.60	0.15	91	1332	4.08	max. F.W turbidity < 0.5 JU

III.2. **With a moderate turbidity raw water (15 to 25 JU max.)**

Micro-flocculation is better than with a low turbidity water: 1 g/m3 of NALCO (cycle 21) gave an acceptable filtered water turbidity whereas 0.8 g/m3 (cycle 22) resulted in residual turbidities over 0.5 JU.

However, the filter run was too short in both cases (9.5 to 13.5 hours).

III.3. **Conclusion**

Direct coagulation on a dual media filter using only a cationic product is not suitable for obtention of a good quality clarified water or sufficiently long filter runs.

IV. AQUAZUR V FILTER FOLLOWING CLARIFICATION OF AN ARTIFICIALLY TURBID WATER (table 15)

To study the performances of the pilot PULSATOR clarifier with highly turbid raw water, we rendered a water turbid artificially using very fine sediment, thus producing raw waters containing 900 to 1110 mg/1.

IV.1. **After clarification with a cationic product only (2.5 g/m3) of NALCO 5 WP** (cycle 30)

At a filtration rate of 14.64 m/hr, the filtered water turbidity exceeded 0.5 JU after *42 hours;* the turbidity remained below 0.7 JU after *75 hours.*

It would have undoubtedly been necessary to use more NALCO to reduce the filtered water turbidity while conserving an acceptable length filter run.

fig. 14

DUAL MEDIA FILTER CONTAINING ONLY CATIONIC POLYMERS WITH LOW OR MODERATE TURBIDITY RAW WATER

Results reduced to V=14.64 m/h with head loss increase of 1.80 m

Cycle N°	Polymer dose and type	Clarific rate m/hr	Filtrat. rate m/hr	Run filter hours	Filtered volume m^3/m^2	Head loss increase m	TURBIDITY (J.U) RW Average	CW Average	FW Average	FW Mini	FW Maxi	Run filter hours	Filtered volume m^3/m^2	S.S. retained kg/m^2	NOTE
1) WITH A LOW TURBIDITY RAW WATER (5 JU max)															
14	1 g/m3 Nalco 5WP	3.26	12.20	28	342	2.52	4.5	3.57	0.53	0.38	0.68	18.4	269	1.02	with contact period in the Pulsator
15	0.6 g/m3 Nalco 5WP	3.26	12.20	33.3	405	2.59	4.4	3.2	0.68	0.47	0.92	21.5	314	0.93	
15bis	0.6 g/m3 Nalco 5WP	3.26	12.20	51	622	2.63	3	2.32	0.61	0.47	1	32.2	471	1.01	
16	0.5 g/m3 American Cyanamid 572 C	–	12.20	50.5	616	2.56	3.2	3.33	0.60	0.35	1	32.7	478	1.63	without contact period in the Pulsator
17	0.5 g/m3 Betz 1190	–	12.20	45	549	2.60	5	5.53	0.57	0.48	1.1	28.7	420	2.61	
2) WITH A MODERATELY TURBID RAW WATER															
21	1 g/m3 Nalco 5WP	–	12.20	24	296	2.58	15	14.7	0.37	0.22	1.2	13.5	198	3.56	without contact period in the Pulsator
22	0.8 g/m3 Average Nalco 5WP	–	17.10	11.5	137	2.49	18	14.15	0.55	0.31	1.0	9.5	139	2.36	

IV.2. **After clarification using aluminum sulfate (180 g/m3) and ASP 6, an anionic polymer (0.3 g/m3)** (cycle 31)

This treatment produced a filtered water of remarkable quality with an average turbidity of 0.15 JU.

The filter run reached a record duration of 91 hours with a clarified water containing 2.6 JU.

The amount of suspended solids retained exceeded 4 kg/m2 of filter with a clarified water containing 2.6 JU. This was the greatest amount retained in all of the tests and even exceeded that retained in the dual media filter used for direct coagulation.

IV.3. **Conclusion**

While both treatments can be applied to turbid water, use of a cationic polymer is much more economical, and although this treatment is possible in a concentrated sludge blanket clarifier such as the PULSATOR, there is no guarantee that it will work in a static settling tank.

V. COMPARISON OF SAND FILTERS AND DUAL MEDIA FILTER OPERATING WITH LOW OR MODERATE TURBIDITY WATER (25 JU max.) (table 16)

V.1. After clarification using the jar test aluminum sulfate dose and an anionic or non-ionic polymer

At a filtration rate of 14.64 m/hr, the results on table 16 reveal that:

- the dual media filter is clearly better than the fine sand filter (cycles 19-5):
  - o it has a filter run of 39.3 hr. i.e. 1.82 times that of the fine sand filter (21.5 hr in cycle 5)
  - o it retains 2.3 times as much suspended solids per m2
- This difference is limited, however, by the remarkably low turbidity of the clarified water supplied by our pilot PULSATOR and the method of washing the fine sand, which remains homogeneous after washing.

Fig. 16

COMPARISON OF A DUAL MEDIA FILTER, FINE SAND FILTER AND AQUAZUR V FILTER

Cycle N°	Type of filter	A S dose	Polymer dose and type	Clarific rate m/hr	Filtrat rate m/hr	Run filter hours	Filtered volume m^3/m^2	Head loss increase m	TURBIDITY (J U) RW Average	CW Average	FW Average	Results reduced to V=14.64m/h with head loss increase of 1.80m: Run filter hours	Filtered volume m^3/m^2	S S retained kg/m^2	NOTE
1) CLARIFICATION WITH JARTEST ALUMINIUM SULFATE DOSE AND A POLYMER (ANIONIC OR NON IONIC)															
19	Dual media	4.0	0.025 [illegible] American Cyanamid	3.26	12.20	62	756	2.62	8.8	1.9	0.14	39.3	575	1.26	with mixer after injection of polymer
5	Fine sand	4.0	0.05 Prosedim ASP6	3.26	14.64	24	352	2.06	5.3	1.5	0.10	21.5	314	0.55	
9	Fine sand	4.0	0.10 Prosedim ASP6	3.26	13.5	16	216	2.05	5.4	1.2	0.15	13.5	198	0.26	
2) CLARIFICATION WITH A LOW ALUMINIUM SULFATE DOSE AND A CATIONIC POLYMER															
24	Dual media	10	0.8 Nalco 5WP	4.25	17.1	72	1231	2.69	20	1.8	0.18	58.4	855	1.76	with mixer after injection of cationic polymer
28	Aquazur V Sand filter	10	0.6 Nalco 5WP	3.92	15.95	87	1383	2.25	9.5	2.0	0.20	74	1084	2.44	
3) CLARIFICATION WITH A MINIMUM ALUMINIUM SULFATE DOSE AND A CATIONIC POLYMER															
25	Dual media	7.5	0.4 Nalco 5WP	3.92	15.55	75	1166	2.49	17	2.9	0.30	58.2	853	2.77	without mixer after injection of cationic polymer
26	Aquazur V Sand filter	7.5	0.4 Nalco 5WP	3.92	15.55	83	1291	2.09	11	2.5	0.35	75.5	1105	2.97	
32	Aquazur V Sand filter	7.5	0.5 American Cyanamid 573C	3.92	15.66	90	1400	2.24	5.7	4.2	0.23	76.9	1125	1.36	

V.2. After clarification using a low aluminum sulfate dose (10 g/m3) and a cationic polymer

This treatment was tested in the dual media filter (cycle 24) and the homogeneous sand filter (0.95 mm effective size) of the AQUAZUR V type (cycle 28) using raw waters having turbidities from 10 to 20 JU.

- Although the clarified water feeding the dual media filter was of slightly better quality than that fed to the AQUAZUR filter, the latter had a filter run of *74 hours* versus only *58.4 hours* for the dual media unit (the filtration rate was 14.64 in both cases).

The AQUAZUR filter thus has a run 26% longer than the dual media filter.

- Likewise, the AQUAZUR filter retained 39% more suspended solids per m2 than the dual media filter.

The AQUAZUR filter is thus clearly better than the dual media filter for this type of treatment.

V.3. After clarification using a minimum aluminum sulfate dose (7.5 g/m3) and a cationic polymer

This treatment was applied in:

- a dual media filter (cycle 25) using 0.4 g/m3 of NALCO 5 WP
- an AQUAZUR filter (cycle 26) using 0.4 g/m3 of NALCO 5 WP and (cycle 32) using 0.5 g/m3 of 575 C from American Cyanamid

The turbidities of the clarified waters were about the same, although that in the water feeding the AQUAZUR filter was slightly lower than that in the water supplying the dual media filter (2.5 JU versus 2.8 JU).

The results obtained using the same dose of NALCO were as follows:

- the AQUAZUR filter had a run of 75.5 hr. versus *58.2 hr* for the dual media filter, i.e. 30% longer at a filtration rate of 14.64 m/hr.
- the filtered water turbidities are comparable, although that from the dual media filter is slightly better (0.30 JU versus 0.35 JU in the water from the AQUAZUR filter)
- the amounts of suspended solids retained are about the same, although 7% higher in the AQUAZUR filter (2.97 kg/m2 versus 2.77 kg/m2 in the dual media filter)

These two filters are thus of comparable technical value. Nevertheless, the AQUAZUR filter leads to longer run times (30% more than dual-media filter) as regards the filtered water quality and the amount of suspended solids retained.

V.4. Conclusions

In resume, the following conclusions can be drawn for the treatments tested:

- the dual media filter is clearly better than the fine sand filter
- on the whole, the AQUAZUR filter is better than the dual media filter, and gives filter runs 26 to 30% longer than the dual media filter for filtered water turbidities which are always below 0.5 JU
- Cycle 27: the AQUAZUR filter was able to work at 8 US gpm without any problem: For example, during cycle 27, clarification was practised with a low dose of aluminium sulphate (10 g/m3) and 0.6 g/m3 of cationic NALCO 5 WP while the rate in the AQUAZUR filter was 19.20 m/hr

(7.85 US gpm/ft2). The turbidity of the filtered water varied from 0.32 JU at the beginning of the run to 0.17 JU with an average increase in sand clogging and was stopped after 38 hours without breakthrough.

VI. GENERAL TEST CONCLUSIONS

All of these tests, conducted over a three and a half month period from November 1975 to February 1976 using various quality raw waters, reveal that:

(1) the fine sand filter (effective size 0.56 mm) is not suited for high rate filtration due to excessively fast surface clogging

(2) Two techniques are available to reach filtration rates of 5 to 8 US gpm/sq. ft., i.e. 12.20 to 19.20 m/hr:

- a dual media filter containing sand and anthracite
- a filter containing a deep bed of sand with an approximate effective size of 0.95 mm, in which the sand is homogeneous throughout the bed and remains so after washing with water and air simultaneously: this is the technique employed in the DEGREMONT AQUAZUR V filter.

(3) For the various treatments envisaged for the water at Balara, the filter runs obtained at a filtration rate of 14.64 m/hr and with a head loss increase of 1.80 m were as follows:

- with the dual media filter:
  - o 18 to 33 hr for direct coagulation of a low turbidity water (7 JU max.)
  - o 9.5 to 15.5 hr for direct coagulation of a more turbid water (15 to 25 JU)
  - o 58 hr after clarification using aluminum sulfate and a polymer
- with the AQUAZUR V filter:
  - o 74 to 77 hr clarification with aluminum sulfate and a polymer

These results give evidence of the reliability of the AQUAZUR filter at the rates of 14.64 m/hr and 19.20 m/hr. Under the test conditions, the AQUAZUR filter gives run times 26 to 30% longer than the dual-media filter for a filtered water turbidity always below 0.5 JU.

(4) During this same period, the fine sand filters at the Balara plant had filter runs of 18 hours with a filtration rate of 12.20 m/hr following static settling using aluminum sulfate and a polymer; this would correspond to 16 hour runs at a filtration rate of 14.64 m/hr.

(5) The long filter runs obtained with the dual media filter and the AQUAZUR V filter are also due to the remarkable quality of the clarified water supplied by our pilot PULSATOR, which operated at rates of 3.26 to 4.33 m/hr, with peaks above 5.62 m/hr over the clarification area.

(6) Finally we showed the possibility of applying, with our PULSATOR clarifier, an especially economical clarification: a low aluminum sulfate dose, between 7.5 and 10 g/m3; and 0.4 to 0.8 g/m3 of a cationic polymer. However, there is no proof that this economical treatment obtained with our concentrated sludge blanket PULSATOR clarifier is also possible with flocculant settling carried out in a static settling tank.

TREATMENT FOR ALGAE REMOVAL FROM POTABLE WATER

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1. Introduction

The Nakdong River is the raw water source for the largest water treatment plant in Daegu, ROK.

Algae growths stimulated by nitrogen, phosphorous and organics contained in industrial and municipal waste discharges to the Nakdong river recently caused filter clogging at the Daegu water treatment plant. The problem is most severe in April and May when the water temperatures are high, turbidity is low (less than 25 NTU) and river flows are low.

During the periods of heavy algal growth in the river, production of potable water is reduced. At present a conventional sedimentation process being used.

A pilot plant was installed to study the effect of flotation on removal of algae encountered at these works, and the results are the here discussed to modify the existing sedimentation tank to a flotation unit before the rapid sand filters.

2. Procedure

2.1 Raw water quality

Table 1 shows the analysis of the raw and treated water after sedimentation with break point chlorination and alum coagulation.

It was found that approximately 89% of the algae are removed by conventional treatment with the sedimentation process, but ABS temains.

2.2 Coagulants and analytical methods

Prepared 1% stock solutions of $Al_2(SO_4)_3$ $16H_2O$,PAC and lime commercial reagent quality and 0.1% solution of the polyacrylamide PA-391.

A Model 100 turbiditymeter was used for turbidity measurement. After samples were treated with a few drops of Lugols iodine solution to inhibit the algal growth, algal counts were made for algae, separated from the samples by a centrifuge.

Item		Raw water	Sedimentation treated water
Temp.	(^oC)	20	20
Turbidity	(NTU)	25	4.5
ABS	(mg/1)	0.24	0.22
TSS	(mg/1)	68	5
pH		7.8	7.2
NO_3–N	(mg/1)	0.8	0.8
NH_3–N	(mg/1)	0.20	ND
PO_4^{-3}	(mg/1)	0.15	0.06
Alkalinity	(mg/1)	40	37.6
Hardness	(mg/1)	65.5	47.6
E. Coli Group	(MPN)	2100	ND
Algae	(cell/ml)	510,000	60,000

Table 1 Water quality of the raw and treated water after sedimentation (June 7, 1980)

2.3 Design of pilot plant

A pilot plant, capable of treating 5 m^3/hr of Nakdong river water, was constructed in order to establish design criteria for scaled up flotation plants. The plant consists of a flash mixer, three-stage mechanical flocculation followed by a rectangular flat-bottomed flotation tank, similar to that employed by Zabel for the water reclamation studies of River Thames water. (1 – 7)

Fig. 1 is a flow diagram of the pilot plant.

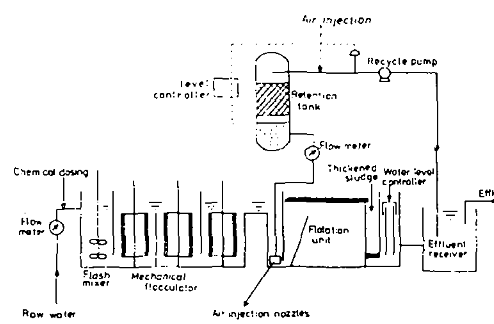


Fig 1 Schematic flow diagram of the pilot plant for the flotation

The retention time in the flocculator is 15 minutes and in the flotation tank 20 minutes. Part of the treated water is recycled, pressurized and saturated with air in a retention tank. The recycle water is introduced to the floculated water in a downflow chamber of the flotation tank through a nozzle in which the pressure is reduced to atmospheric pressure.

Floated sludge is continuously removed by an electrically-driven skimmer. The water level in the flotation tank is maintained using an adjustable level control weir and the treated water is drawn from the bottom of the flotation tank.

The optimal operating conditions the pilot plant are given in Table 2

Table 2 Optimal conditions for flotation

Operating pressure (p)	4 Kg/cm^2
Recycle ratio (%)	12
Detention time for flotation (min)	20 – 25
pH for coagulation with alum	7.2

3. Results and discussion

3.1 Algae in river water

Algae in the river water are mainly classified into three algal groups which are shown in Table 3.

Table 3 Classification of algae mainly distributed in river water.

Algal group	Algal genus
Green-Algae	Tetraedron regulare Westella botryoides Microeoleus Tetraspora Chlorella Scondemus Gomphosphaeria Stichococcus Spondylosium maniliforme Zygnema pectinatum Casmarium circulare Spirogyra
Blue-Green Algae	Anabaena flos-aquae Aphanizomenon Phorimidium Anacystis Lyngbya Coccochloria Oscillatoria
Diatoms	Cyclotella Asterionella Synedra sp. Navicula Gomphoma Fragilaria crotomensis Achnamthes lanceolata Molosira italica Cocconeis pediculus

The important filter-clogging algal genuses are found from Table 3. These include Chlorella, Spirogyra, Anabaena, Oscillatoria, Cyclotella, Synedra, Navicula and Fragilaria.[8]

The algal growth in Nakdong river water varied considerably during the seven month period of the investigations. Throughout most of the study, the algal growth was dependent on the turbidity in the raw water as shown in Fig. 2.

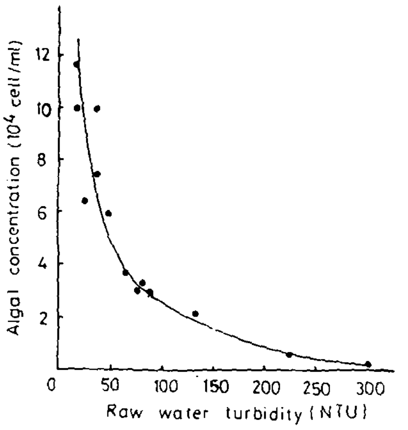


Fig. 2 Relationship between the turbidity of the raw water and the algal concentration

When the turbidity of the raw water was less than 25 NIU, algal counts of more than 10,000 cell/ml were found. At flood conditions with turbidity higher than 100 NTU the algal growths are considerably reduced.

3.2 Removal of turbidity

The residual turbidities of the flotation treated water with alum and PAC at various pH range are shown in Fig. 3.

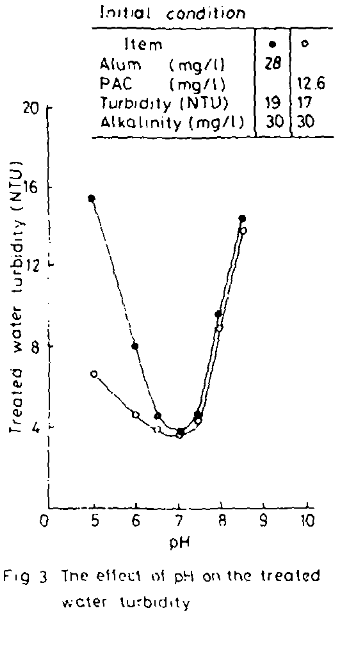


Fig 3 The effect of pH on the treated water turbidity

The optimal flotation conditions for raw water having 19 NTU turbidity and 30 mg/l alkalinity are obtained using an alum dose of 28 mg/l and pH adjustment between 6.5 and 7.5. By using PAC as coagulant, the removal of turbidity is achieved at a wide range of pH.

Pilot plant trials were performed using alum plus polyelectrolyte as coagulant. The results show that by using alum plus polyelectrolyte satisfactory treated water turbidity is produced compared to using alum alone. When using a dose of 35 mg/l alum and 0.5 mg/l of PA-391, the raw water turbidity is reduced from 65 NTU to 2 NTU as shown in Fig. 4.

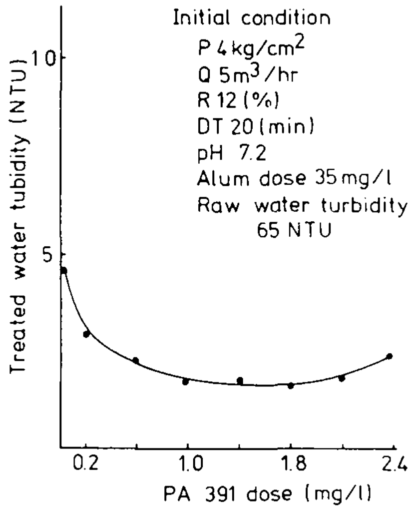


Fig. 4 The effect of polyelectrolyte on the treated water tubidity

3.3 Removal of algae

The removal efficiencies of algae are compared for a variety of coagulants; alum, PAC and alum plus PAC. Fig. 5 shows that algae are removed to more than 95% in most cases at suitable flotation conditions.

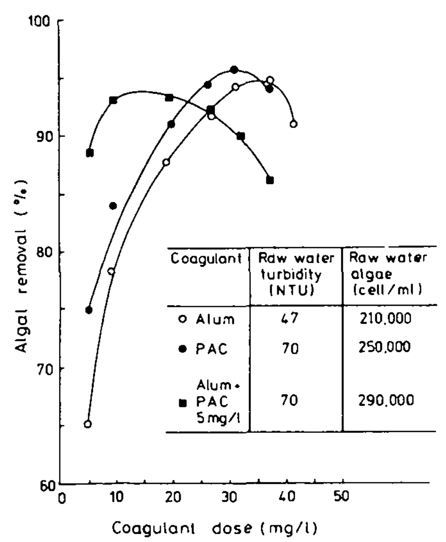


Fig 5 Comparision of algae removal with the various coagulant dose

It is found from Table 1 that the surface-active agent, ABS is not removed by the sedimentation process. Fig. 6 shows that 2500 cell/ml of algae remain after floatation of raw water containing algae of 62,500 cell/ml and ABS of 0.24 mg/l using 8 mg/l of alum at pH of 7.2 under the same conditions the remaining algae is reduced to 750 cell/ml by the addition of 1.0 mg/l ABS. It is concluded from these results that flotation compared with sedimentation has a greater ability to remove algae and also to remove ABS in the raw water.

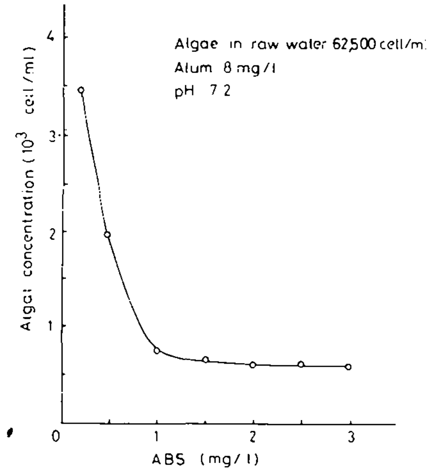


Fig 6 The effect of ABS on the algal concentration of the treated water

3.4 Comparison between the sedimentation and the flotation process

One of the most important processes for the water clarification is the coagulation process, in which the flocs are separated either by sedimentation or flotation. To compare the removal efficiency of algae with the flotation and the sedimentation process Fig. 7 presents the individual algal genus contained in the treated water. In this experiment alum was used as a coagulant.

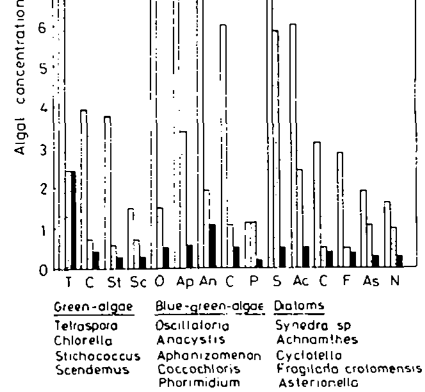


Fig 7 Removal efficiency of the various algae after the sedimention or flotation treatment

Tetraspora belonging to the green algal group is equally removed in the both processes, but in the case of other algal genuses studied, the flotation process achieved better efficiency than the sedimentation process. Particularly as shown in Fig. 7 the blue-green algae such as Aphanizomenon and Phorimidium, and the diatoms such as Synedra sp and Achnamthes are successfully removed with the flotation process, while with the sedimentation process the removal efficiency is low. Therefore, we can conclude that these algal genuses are a cause of filter clogging, when the conventional sedimentation process is used.

Table 4 shows the mean values of the residual algae of treated water after flotation or sedimentation, during the seven months from May to October in 1980.

When the pilot plant facilities are operated at the optimal conditions for specific influent turbidity less than 20 NTU, the flotation process removes approximately 96% of algae contained in the raw water. Whereas, the sedimentation process removes only 82% under comparable conditions, even though 0.1 mg/1 residual chlorine remains. The flotation process also results in better treatment for algae removal than the sedimentation process with raw water of high turbidity.

Fig. 8 shows seven months of algal distribution of the raw water from the Nakdong River. The algal growths increase in May, June and September, the dry months. It is found that the algal growths suddenly decrease in July the flooding period and after October, the low water temperature period.

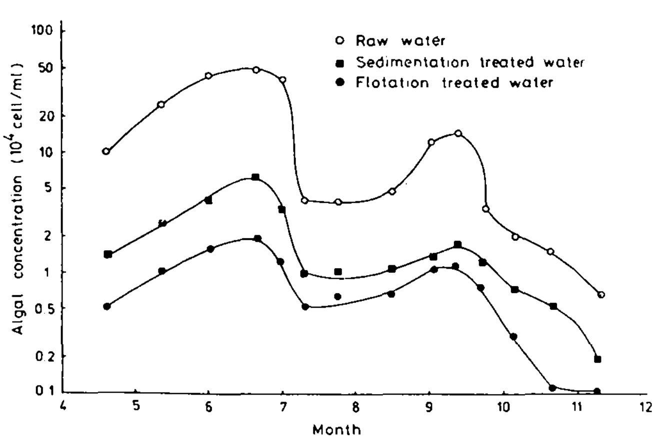


Fig 8 Efficiency of algal removal with the flotation or sedimentation treatment for each month

During each month the efficiency of algal removal by flotation is generally much better than the sedimentation process. Dissolved air flotation is particularly effective for algae removal during the peak algae bloom in June.

Table 4

COMPARISON OF ALGAL REMOVAL WITH THE FLOTATION AND SEDIMENTATION PROCESS

	Raw water		Flotation treated water			Sedimentation treated water			
	Algae log cell/ml		Algae log cell/ml		AR	Algae log cell/ml		AR	RC
Turbidity (NTU)	Range	Mean	Range	Mean	%	Range	Mean	%	(mg/l)
8 – 20	4.53-5.22	5.11	3.00-3.69	3.67	96	3.11-4.84	4.34	82	0.1
20 – 70	4.33-5.14	4.93	ND-3.90	3.56	94	ND-4.14	3.83	90	0.3
70–120	4.62-4.65	4.63	ND-3.69	3.20	95	ND-3.74	3.52	92	0.5

AR (%) : Algal removal
RC (mg/1) : Free chlorine residual
ND : Indicates none detected of algae

The mean values of the water quality in September are shown in Table 5, in which the removal efficiencies are compared with the raw, flotation and sedimentation treated water.

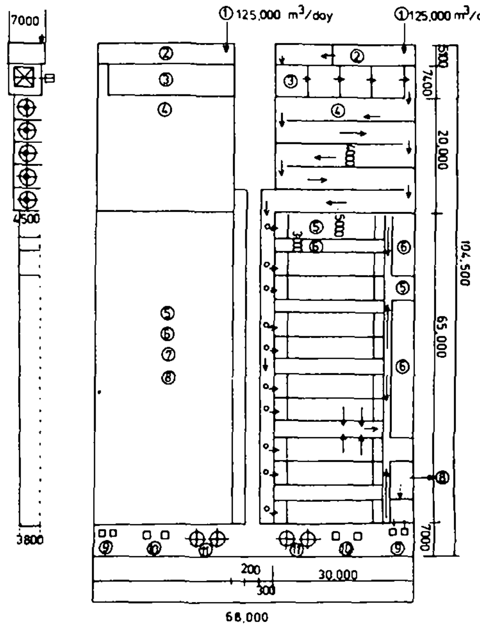
Table 5 means values of water quality of the raw, sedimentation and flotation treated water (Sep. 1980)

Item		**Raw water**	**Sedimentation treated water**	**Flotation treated water**
Temp.	(°C)	19	19	19
Turbidity	(NTU)	30	4	4.5
ABS	(mg/1)	0.28	0.27	0.01
TSS	(mg/1)	67	4.4	4.4
pH		7.8	7.2	7.2
NO_3-N	(mg/1)	0.8	0.8	0.8
NH_3-N	(mg/1)	0.20	0.15	0.13
PO_4	(mg/1)	0.16	0.07	0.07
Alkalinity	(mg/1)	40	37.6	37.6
Hardness	(mg/1)	65.5	46.5	48.0
E. Coli Group	(MPN)	2,200	ND	250
Algae	(cell/ml)	120,000	18,000	8,000
COD	(mg/1)	3.8	2.0	2.0
BOD_5	(mg/1)	3.7	2.1	2.1

It is also show in Table 5 that the sedimentation process results in slightly better removal of turbidity than flotation, but for the removal of algae and ABS the flotation process give better results. In general, the other drinking water quality parameters show no difference between the processes.

3.5 Design for algae removal facilities

Fig. 9 is a model of the flotation facility proposed to temporarily modify the conventional sedimentation tank, which is now used to treat river water at the rate of 250,000 m^3/day. Approximately 104.5 m x 68 m in surface area is needed to construct the flotation plant, arranged into two parallel series and each series capable of treating about 125,000 m^3/day river water. The raw water is coagulated with alum at the first stage of flash mixing and at the second stage of flash mixing pH is controlled with lime. After the complete mixing of chemicals, flocculation is achieved through the five-stage mechanical flocculation tank of rectangular shape divided into five equal compartments. On leaving the flocculation, the water is



① Raw water
② Flow meter
③ Rapid mixing tank
④ Flocculation tank
⑤ Flotation tank
⑥ Treated water
⑦ Sludge tank
⑧ Treated water effluent
⑨ Sludge pump
⑩ Compressor
⑪ Pressured tank

Fig.9 Flotation diagram proposed to modify the sedimentation process

introduced separately into ten flotation tanks, here the sludge containing algae is removed. Clarified water is withdrawn near the bottom.

Although the flotation experiments show promise as a solution to the algae problem at Daegu, prior to committing any budget, additional investigation is required on other potential solutions, as well as examination of operating flotation systems and economic comparisons of all processes.(9, 10)

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Abstract

Algae growths stimulated by nitrogen, phosphorous and organics contained in industrial and municipal waste discharges to the Nakdong River cause filter clogging at the city of Daegu ROK water treatment plant. The problem is most severe in April and May when the water temperatures are high, turbidity is low less than 25 NTU, and river flows are low.

A pilot plant study was conducted to optimice the dissolved air flotation process for removal of algae from the raw water. The 5 m^3/hr facility was operated for six months during which time the process was optimized with respect to percentage recylce of treated water, alum and polyelectrolyte dosage, operating pressure, flotation cell detention time, air to solids ratio. When the pilot plant facilities were operated at the optimum conditions for specific influent suspended solids the flotation process removed approximately 96% of the algae contained in the raw water. Conventional coagulation-flocculation and sedimentation process removed only 82% under comparable conditions. Dissolved air flotation is particularly effective for algae removal during the peak algae bloom in June. Addition at polyelectralytes and continuous removal of flotation sludge improved algae flotation.

The pilot plant studies were useful in determining design criteria for full scale algae removal facilities at Daegu water treatment plant.

OZONE IN WATER AND WASTE WATER TREATMENT

by ALAIN DELCOMINETTE

International Operations
Trailigaz - France

Everybody knows how important for life is water; pure, it is a necessary material; when not, it can lead to some diseases or even to death. So, metallic elements as lead or mercury, organic compounds as some pesticides and herbicides, are able to induce several kinds of poisoning. Among micro-organisms, bacteria, parasites and viruses present in waters, are responsible of various diseases or dysenteries and endemic hepatitis.

If we notice that on one side, there is a specific relation between dosages and effects for these elements, and that on the other side, it looks necessary to keep a minimum level of some minerals (as calcium and magnesium) into water, we can guess how important and how difficult it is to depurate raw waters so that to allow their safe delivery.

Water treatment has grown up with industries. Simple disinfection or sole filtration in the old days, purification is now a more sophisticated treatment. Generally, it combines several steps as physical, physico-chemical and even biological ways.

Chlorine has been used for a long time for oxidization and disinfection purposes; its appliance in the treatment process is changing as ozone is more and more moving forward. So, we have to consider some ozone and ozonization aspects.

Ozone is the result of the combination of three atoms of oxygen and its formula is 0_3. Under usual utilization conditions the ozone gas is diluted in the gas mixture used for its synthesis (air, oxygen, etc.).

Ozone is much more soluble than oxygen. Different factors affect ozone solubility, such as high temperature, low pH and high content in oxidizable matter which lower its dissolution.

Known as an instable gas, ozone redecomposes in oxygen, when present as well in gaseous as in liquid phases. In air, its decomposition kinetic gets slower with low concentrations; different parameters act as destruction catalysts: the main ones are metals like silver or platinium, caustic soda, nitrogen pentoxydes, chlorine, bromine. . .

Though, ozone decomposition is much more effective in water; basic pH and high temperature accelerate its destruction. Above 70°C, its decomposition in distilled water is nearly immediate.

A summary about ozone properties should be incomplete if chemical characteristics were not mentioned.

With the highest oxydo-reduction potential (Eo + 2.03 volts) after fluorine E'o = 2.85 volts), ozone has two principal applications: oxidization and disinfection. It acts according four main ways:

- direct oxidization: one of its three oxygen atoms are used,
- ozonolysis: there is fixation of ozone molecule on a non saturated bond: an ozonide is created; because of its instability, it quickly decomposes into two compounds in water (Criegee mechanism),
- catalysis: ozone lowers the activation energy and enhances kinetics of reaction with oxygen,
- radicals formation: according to water parameters, ozone becomes source of hydroxyl and hydroperoxyl radicals which themselves react with some of the compounds.

All these descriptions give an overview of the various and complex reactions involved in water treatment with ozone.

Ozone synthesis

As mentioned previously, ozone is a gas which is always diluted in a gaseous phase. Its synthesis takes place when oxygen molecules are submitted to an electric discharge (or corona discharge).

Generally speaking, an elementary ozonizer is composed with two electrodes with a small interval between them; a thin and solid dielectric is stuck against one or against the two electrodes. In these conditions, if a mixture of gas containing oxygen is flown through this interval and if a high alternative voltage is applied between the electrodes, a violet light can be seen, which is representative of the corona discharge that generates to ozone.

Industrial ozonizers consist of many elementary ozone generators coupled together. The biggest ones which are of the tubular type can produce up to 85 kgO_3/h from oxygen at a 600 Hz frequency: this is actually a world record.

Two factors are very important in an ozone generator efficiency: ozonizer cooling with water, and air pretreatment before electric discharge.

In fact, ozone synthesis produces heat which has to be taken away to avoid ozone destruction; this is done with cool water flowing through the ozonizer.

When air is used for ozone generation, it has to be purified so that to better the efficiency, to avoid working troubles and to lengthen lifetime of the materials. Three parameters are of the greatest importance, and must not be present in gas entering the ozonizers: dust, oil or water (dewpoint less than minus 60°C).

All this gives an explanation for air pretreatment process: first, air is dedusted and compressed; then it is water cooled and sometimes also by freon to get rid of moisture. Finally, air flows through a drier (filled with activated silica or alumina) to absorb rest water molecules. The drier has two columns: one is in operation while the other one is in regeneration by heat and air. Exchanging is fully automatized.

So pretreated air is ready for ozonization, as described before.

DRINKING WATER TREATMENT

There are many applications of ozone to the treatment of drinking water all over the world. Millions of cubic meters of water are ozonized every day, and this implies ozonization of waters originating from very different sources and treatments for various final purposes.

Figure I shows the various possible reaction stages in the treatment of water as well as their possible relations with ozonization. There are three main purposes for the use of ozone: oxidizing, improvement of other treatments and disinfection. In the first and third case ozone has a direct action whereas in the second, ozone is used to improve a treatment taking place later: either storage, or floculation or even a biological filtration.

Ozonization: a treatment step in the process

Due to its very high oxido-reduction potential, ozone happens to be a strong oxidizer, which accounts for its use at the beginning of a treatment line in some cases. Moreover, ozonization can be a means of substitution of chlorination at the head of a treatment process. In fact, chlorine leads to the formation of chloro-compounds the toxicity of which, has been evidenced in many cases. Therefore, at the beginning of the treatment line, ozonization (pre-ozonization at that particular point) contributes to the decrease in colour and turbidity as well as in concentration of mineral elements such as iron and manganese. On the other hand, it destroys some organic compounds such as phenols, detergents, pesticides, etc... bringing its contribution to the reduction of micropollution. It would be boresome to describe all the applications of ozone, and this is why only a few examples are presented.

Colour, turbidity and taste elimination

The colour of water may come from various origins, most frequently from vegetals. Surface waters, more particularly standing waters get loaded with humic matters that tend to leave colours ranging from brown to greenish. When chlorination is applied, these organic matters account for the formation of trihalomethanes some of them are mutagenous or even cancer inducing. While breaking these molecules – more particularly the chromophoric groups – ozonization is successful in decreasing the colour of water.

There are many examples of the efficiency of ozonization against turbidity. In general the kinetics of oxidizing are exponential: quick at the beginning, they tend to rapidly become asymptotic. This may account for the low values of treatment rate and dissolution time that are often used.

Iron removal and manganese oxidization

Ozone oxidizes iron efficiently. Iron then precipitates into non-soluble hydrates. The reaction is very rapid when iron is not or only slightly complexed, which is the most frequent case. Otherwise, it is necessary to carry out a gradual ozonization: discontinuous injections of ozone first release iron which is in turn oxidized in a second stage.

In the case of manganese, various degrees of oxidization can be obtained. The most oxidized form is permanganate which is soluble in water and gives it a colour ranging from pink to violet according to concentration. Among the intermediate stages of oxidizing we should mention manganese dioxide which is a colloid and gives a champagne colour to water.

In practice, three stages are necessary to eliminate the most part of manganese: first, ozone oxidizing transforms it into dioxide and permanganate; second, some water retention time, allows reducing permanganate into manganese dioxide; finally, a filtration process – possibly through catalytic sand (sand coated with manganese dioxide) – separates manganese from water.

Pre-ozonization influence on some other parameters

In addition to the fact that pre-ozonization decreases turbidity and manganese concentration as already mentioned, it should be noted that it reduces COD, BOD, and anionic detergents, for instance.

Ozonization by itself results therefore in an overall improvement in the quality of water, and this improvement can even be felt after all the various stages of treatment. Moreover, use of pre-ozonization on loaded water allows savings on reagents: savings on post-ozonization ozone and savings on flocculation agents; ozone induces floculation by itself according some conditions.

Ozonization: a means of improving other treatments

Storage, biological or non-biological filtration and floculation are the principal water treatments that can be bettered by pre-ozonization.

— Ozonization and flocculation/filtration

By modifying the zeta potential of ozone entails the formation of a floc which is easily strained by filtration. This depends on the composition of organic matters in water. In particular, this phenomenon is noticeable in lake or dam waters.

However, most of the time it is necessary to add a flocculating agent, although its amount can be reduced when ozone is used as already mentioned.

— Ozonization and storage

When surface water contains a large proportion of organic matters, the use and improvement of natural self-purification can be of advantage: the bacterial activity results in a better quality of raw water stored in a reservoir.

The use of ozone before storage yields the following twofold advantage: oxygenation and increase in the biodegradability of dissolved organic matters.

Ozonization has a positive effect on the breakpoint chlorination rate as well as on the ozone rate for post-ozonization. The combined "ozonization and two days storage" treatment used in the Mery-sur-Oise plant in France has offered the best economic results in the case under consideration: .31 to .38 gCl_2/gO_3 less injected and .25 gO_3/gO_3 less injected in post-ozonization.

Although results may vary with time this example shows that the general results are still largely positive.

— Ozonization and biological filtration

The use of porous filtering materials has promoted the retention of bacterias in filters and hence the biological purification of water. In this case, pre-ozonization will serve the same purposes as in the preceding case: oxygenation of water and improvement in the biodegradability of dissolved organic matters. It appears that ozonization by itself entails a reduction by about 10% and more provided that it is made after prior clarification without activated carbon. More variable results are obtained when we compare filtration on activated carbon according to whether there is pre-ozonization or not; results are first similar, then reductions differentiate increasingly with time. As a rule, pre-ozonization is all the more positive when some time has elapsed after filtration on activated carbon has started. Whilst ozone seems to promote indirectly bacterial growth, it can also be used for the opposite purpose, that is water disinfection.

Ozonization: a means of disinfection

This is one of the oldest applications of ozone. In this respect it should be recalled that as soon as the beginning of this Century (1906), the City of Nice (France) already treated the water of river Vesubie with ozone. Since that time, many studies have supported the fact that ozone is a very powerful bactericide and virulicide agent. Figure IV shows a few examples among those mentioned in Literature. These indicate the kinetics of disactivation of poliovirae, Escherichia Coli and spores according to time and ozone residual in water.

It is on the basis of the works of Coin, Gomella and Hannoun that the bactericide and virulicide conditions (also referred to as "true ozonization") have been defined (figure V). They essentially consist in maintaining a free dissolved ozone residual of .4 mgO_3/l during a minimum of 4 minutes. In practice, ozonization is made in two stages of injection: a first stage of 2 minutes satisfies the short-term chemical ozone demand and therefore yields a residual of .4 mgO_3/l. This stage is essentially an oxidizing stage. In a second stage, this residual is maintained during 4 minutes: this is the main disinfection stage.

This technique which is widespread in Europe – more particularly in France – offers several advantages. As it takes place at the end of a treatment process, it contributes to the delivery to the consumer of a water presenting a very high bacteriological quality, and eliminates at the same time the viral risk, which is not the case of the other usual disinfecting agents. On the other hand, it is during this stage that the organoleptic qualities of water are considerably improved. Water becomes colourless or slightly blue, odourless most of the time and without any particular taste.

An example of water disinfection with ozone can be briefly described. It concerns the plant of the Public Authority Board of Singapore CHOA CHU KANG, which treats the water from various reservoirs (Kranji, Pandan, Tangeh). The plant consists of two units capable of treating, for the first one 50 MGD and 33 MGD for the second one. The ozone plants produce respectively 47 and 24 kgO_3/h allowing treatment rates between 3.8 and 5 gO_3/m^3 of water.

The first ozone plant was commissioned in 1979 and the last one was commissioned in 1981.

Among the classical applications of ozone apart from drinking water, it is important to mention waste water treatment and odour control specially using the combination of ozone oxidization and water washing.

WASTE WATER TREATMENT

Three kinds of pollution are responsible of the contamination of wastewaters: they come from organic and mineral matters but also from microorganisms. If the two first ones are well known from wastewater treatment people, it is only recently that many disinfection studies have shown the feasibility and allowed the building of such plants for germs elimination.

In fact, such complementary tertiary treatments can be justified by the sanitary problems which sometimes occur when wasterwaters with high contents in germs are released in nature. So, in France, according to July 7, 1970 legislation, wastewaters treatments have to be completed so that to eliminate part of microorganisms, and particularly pathogenic bacteria and viruses.

Among the different ways of treatment, ozonization appears to be one of the most promising, that explains its growing on, particularly in the United States of America, Japan and Middle East.

Though its powerful action, ozone is more often used for breaking down some compounds the toxicity of which is well known, than for lowering the organic content as measured by classical methods (chemical oxygen demand, total organic carbon, . . .). When obtained, this partial elimination must be considered as a consequence but not as a purpose.

Among ozone applications, detoxifying (elimination of cyanides, phenols, heavy metals, . . .) and decolorization are frequently found in the wastewater treatment field.

Cyanides destruction –

According to Wilson, 25 p.p.b. cyanides are a toxic dosage for fish on which they act as strong enzymatic inhibitors.

Cyanides are frequently present in effluents from many kinds of industries: minerals flotation, chemical synthesis, pharmaceutical fabrications,. . . But they essentially come from electroplating industries. Thus, their different effluents (from electrolyting baths, from washing units, . . .) may contain cyanides as high as 20 to 100 mg/l. Their destruction by ozonization is a two steps oxidization: first cyanides in cyanates and then decomposition of these.

Cyanides destruction require one molecule of ozone per molecule of cyanide. Optimization takes place if the following conditions are fulfilled:

- basic pH of the solution (between 9 and 12).
- presence of metallic irons (copper ones as a preference)
- initial cyanides content less than 0.1 g/l.

Among industrial treatment plants in the world, one notice that since 1957, Boeing Company uses ozone at Wichita (United States of America) for eliminating dyanides in its wastewators.

Phenols elimination –

Phenols are the second group of compounds frequently present in industrial effluents. Cokeries, refineries, mining, food canning, painting units, . . . have all phenolic elements in their wastewaters. When released in rivers, they can induce some toxicity towards aquatic life. Moreover, phenols are precursors of undesirable tastes and smells which can be enhanced by chlorination. This formation of chlorophenols does occur when such waters are pumped and treated with chlorine for producing tap water.

One of the ways for phenols destruction consist in ozonizing. When complete, this oxidization with ozone gives oxalic acid and oxygen. Generally, 5 parts of ozone are necessary for the destruction of 1 part of phenols, mainly because other present oxidizable matter and by-products from phenols degradation are ozone consumers.

Colour removal –

It would be boresome to enumerate the numerous soluble organic elements which colorize waters; they can have a natural origin (humic acids, lignins, . . .) or an artificial one (synthetic colouring agents). When oxidizing them, ozone modifies the elementary structure of their chromophoric groups that transfers absorption from visible to ultra-violet regions.

As for artificial colouring agents, their degradation by ozone cannot be quantified nor generalized. Though, breaking nitrogens double bonds is often noticed when decolorization occurs.

All these remarks lead to the following conclusions:

- soluble colorizing agents, as direct acid or basic ones are quickly and completely

eliminated by ozonization,
- non-soluble colorizing agents are slowly and uncompletely destroyed with zone.

So, after a classical depuration, ozonization can be an excellent tertiary treatment for removing colours from industrial wastewaters.

— Other treatments with ozone

All the different ozone applications we have described, make use of ozone as the only agent for a well defined purpose; but, there are other applications where ozonization can be combined with another treatment.

Such is the case for a biological treatment with a slight preozonization; as an example, the only opening of the phenol ring is sufficient for giving the molecule a biodegradable property. Moreover, ozonization oxygenates wastewater that is another favourable condition for a further biological treatment, as by activated sludge. In this case, three molecules of ozone per molecule of phenol are enough; so phenols elimination becomes more economical and competitive.

Another example is given by the "preozonization-flocculation" process; this technique has been studied for the elimination of heavy metal from mine drainage.

Ph is essential and it must be adjusted according to the elements to remove. The combined treatment "ozone and lime" precipitates free or complexed metals as hydroxydes.

Another case of combined ozonization is given by preozonization followed by filtration. Such a way of treatment can be applied to waters where resins and other organic matter giving polymers, are present. Filtration retains these ozone made insoluble compounds.

When filtration is a biological treatment. ozone enhances bacteria activity in the filters in giving more oxygen and more biodegradable substrata.

All these examples are not complete, but they give an idea of the different main applications of ozone for oxidization. In fact, one must not forget that wastewaters disinfection is often another purpose for ozonization.

WASTEWATER DISINFECTION WITH OZONE

In health terms, wastewaters disinfection is a prophylactic action against diseases due to pathogenic microorganisms; this action must take place before human contamination so, at the outlet of primary or secondary treatment plants where there is the largest proportion of bacteria and viruses.

Many fundamental questions remain answered: how much is the smallest infecting quantity of microroganisms? What kind of pathogenic germs is the most representative?

Practically, most of regulations require an average level of 200 faecal coliforms by 100 ml in wastewaters emitted in critical places (bathing or shellfish growing places); so, sanitary problems are reduced signifcantly.

As for most of ozonization application, it is necessary to make experiemnts. The best way is to use a pilot plant so that to define the optimum conditions for ozonization, and more precisely the necessary ozone dosage.

Among many others the two following plants have an ozonization step included in their process:

Chino basin (U.S.A.)

Situated at 75 km far from Los Angeles, Chino Basin wastewater plant treats 19,000 m^3 of effluent per day.

Since May 1978, a tertiary treatment including ozonization has been applied so that to get a very high quality for the so treated effluents; in fact such effluents may be reinjected underground and reused, or sent into Santa Anna River which is used for recreative purposes.

After ozonization, the wastewaters are flocculated and filtered. Finally, a chlorination is made for enhancing bacteria elimination. Previous experimentations on two pilot plants have clearly demonstrated the multiple purposes for ozonization which are:

- decolorization: most of the coloured compounds of a secondary effluent, are double bond bearing or have aromatic cycles or heterocycles with chromophoric groups. Very often, polar, they induce a coagulating agent demand. Their oxidization with ozone, reduces the colour but also lowers the quantity of aluminium sulphate which is needed.
- Partial removal of turbidity and suspended solids: colloidal elements and suspended solids interfere with virus elimination by coagulation, thus creating a higher demand in aluminium sulfate. Ozone oxidizes part by means of flotation with foams.
- Disinfection: according to the applied conditions, ozone considerably reduces the germs number: 99.5% for total coliforms and 99.9% for poliovirus type I.

It should be added that ozonization also lowers the injected quantities of chlorine and aluminium sulfate: not only savings are made, but also dissolved salts level and chloro-compounds content are significantly reduced.

Jubail (Saudi Arabia)

Located in the North of Dharhan, the first Jubail waste water plant will treat daily 62,000 m^3 (80,000 under the peak conditions) of effluents.

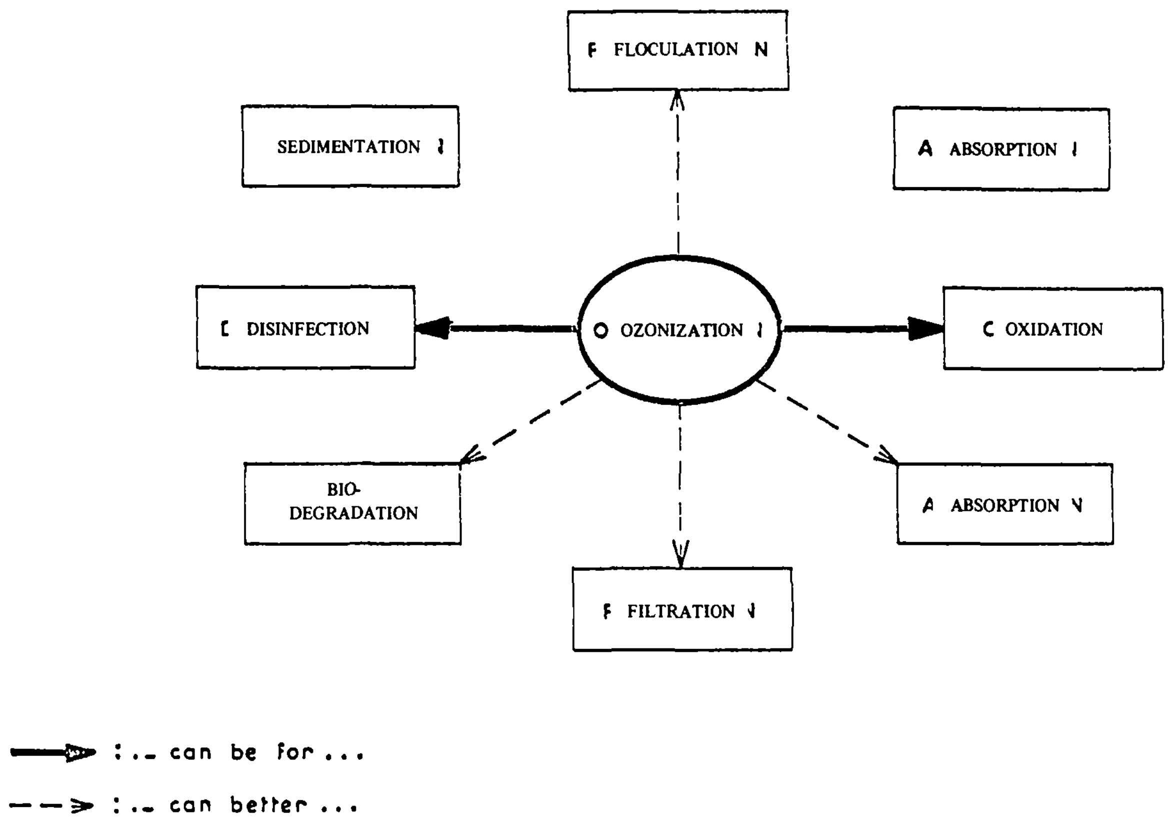


FIGURE I

OZONIZATION AND DIFFERENT REACTION STEPS IN WATER TREATMENT

The ozone plant has a capacity of 40 kgO_3/h. Ozonization is used as a disinfection step, specially interesting when effluents are reused for irrigation purposes.

This project fully demonstrates the efficiency of ozone treatment in wastewater specially when natural raw water resources problem becomes critical.

Conclusion

Ozonization is very often considered as a new technology, but 80 years of applications on large scale basis could show the contrary.

More than 20 million m^3 of drinking water are daily ozonized in the whole world and this a proof of the reliability and efficiency of ozonization.

Recent improvements in power consumption of ozonization plants coupled with benefits brought by ozone when applied not only as a last step make ozonization economical when considering the overall treatment process.

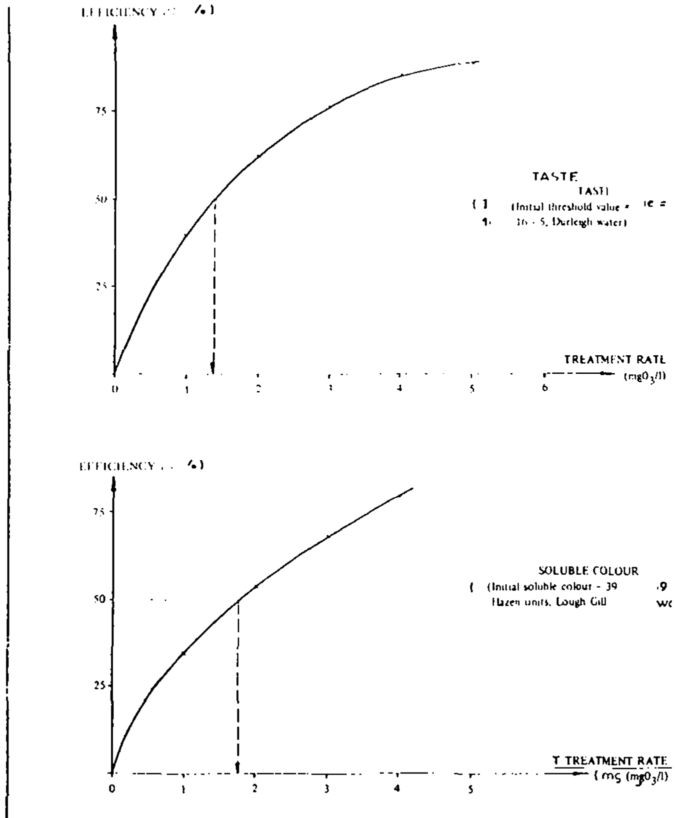


FIGURE II

OZONE INFLUENCE ON TASTE AND SOLUBLE COLOUR REMOVAL

(From Barker and Palmer)

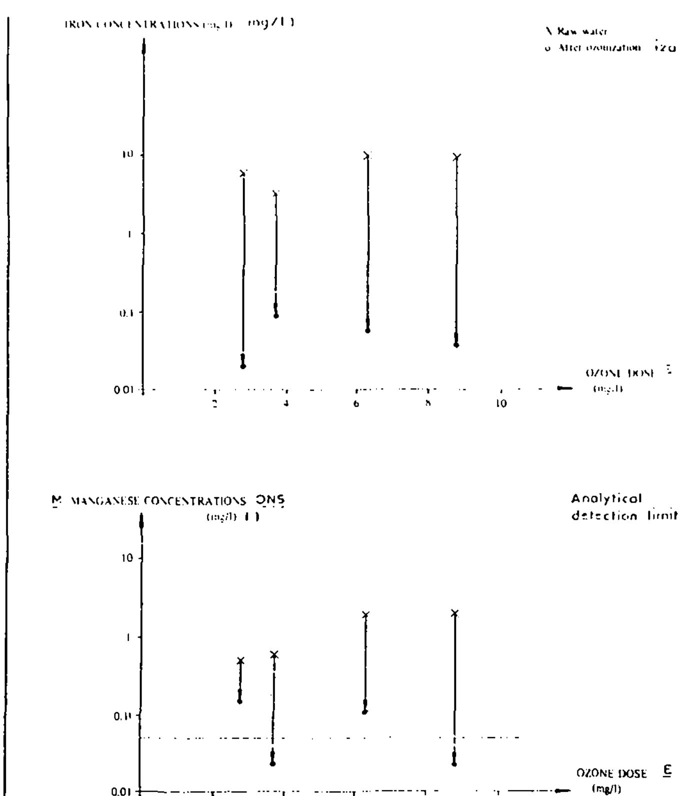
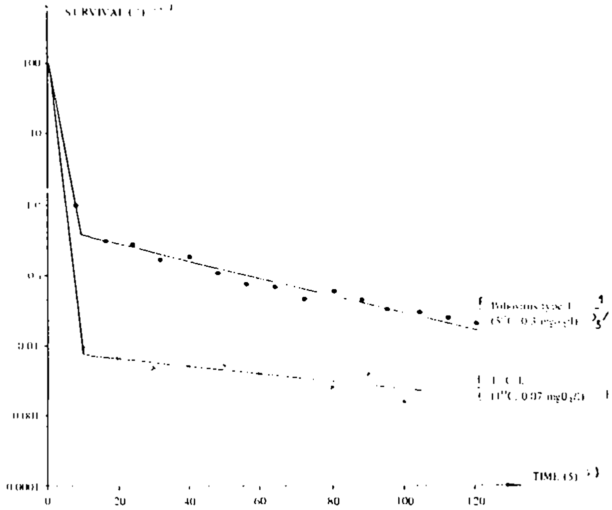


FIGURE III

REMOVAL OF IRON AND MANGANESE IN WELL WATER BY USE OF OZONE (From Furgason and O. Day



INACTIVATION KINETICS BY USE OF OZONE
(From Katzenelson Kletter and Shuval)

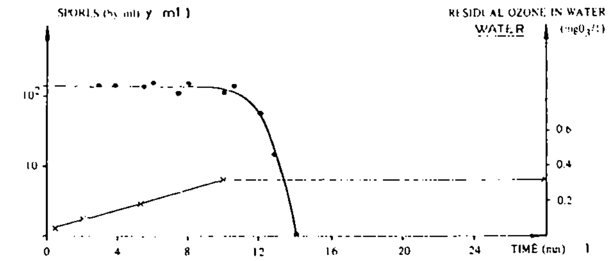
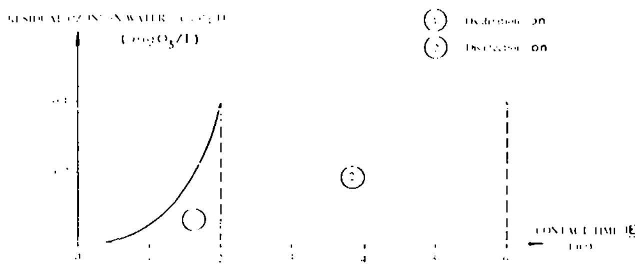


FIGURE IV

INACTIVATION AS A FUNCTION OF TIME AND RESIDUAL OZONE IN WATER
(From Drapeau and Paquin)



TRUE OZONIZATION CONDITIONS IN WATER TREATMENT

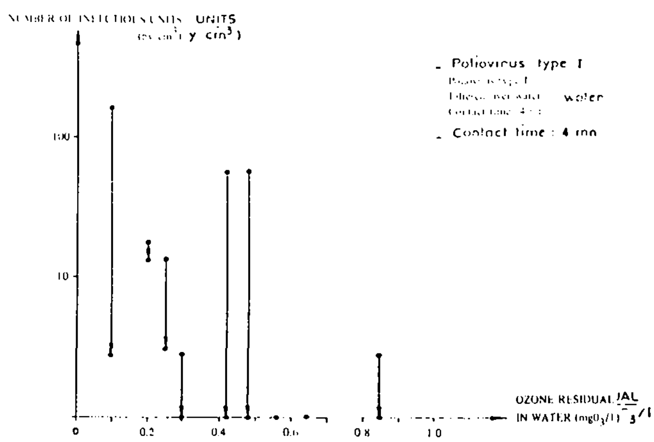


FIGURE V

POLIOVIRUS INACTIVATION BY USE OF OZONE
(From Coin, Hannoun and Gomella)

WATER SUPPLY DEVELOPMENT OF METRO CEBU

by ALFREDO R. VELOSO

General Manager
Metropolitan Cebu Water District
Philippines

Introduction

The signing of PD 198 into law by His Excellency the President of the Republic of the Philippines marked the pivotal event in the history of the development of Metro Cebu Water District or any existing water district in the country today. It signaled a major transformation in the concept and manner of how Water Districts should be operated, maintained and managed more effectively with less political interference from city, municipal, or provincial government.

In Cebu, the defunct Osmeña Waterworks System after more than a half century of existence by virtue of PD 198 became the Metropolitan Cebu Water District.

Under the new management and assisted by the Local Water Utilities Administration, a national entity created under the same Presidential Decree to assist and support on the National level every Water District along the areas of technological services and financing, arranged for a loan with ADB and therewith engaged the services of foreign consultants to provide MCWD with the much needed expertise and knowledge in water facilities design, geological and hydrological investigation services on ground water supply and development. And now after over half a decade of existence people might ask what has MCWD accomplished? What are the new task ahead, the challenges it has to face, and its future plans? The answers to all these questions will be discussed shortly, but let us first take a glimpse of the historical background of the defunct Osmeña Waterworks System.

OWS Historical Background

The Osmeña Waterworks System known today as MCWD came into existence by virtue of Legislative Act No. 2009 passed and approved by the Philippine Legislature on Dec. 22, 1910. The act authorized the Municipality of Cebu to incur an indebtedness of $125,000.00 by means of issuing bonds. The amount was to cover the construction of a dam across the Buhisan River situated in the barrio of Buhisan some 8 kilometers away from the Municipality of Cebu. The amount also included the cost of the transmission mains and distribution system.

The construction started in 1911 and was finished in 1912. It got its name Osmeña Waterworks System from the then Congressman Sergio Osmeña, Sr. who sponsored the legislative act. The finished dam had a crest elevation of 107 meters and an impounding capacity of 308,000,000 gallons when filled to the brim. At this juncture there was a necessity for the raw water supply coming from the dam to meet the standard quality and potability requirements hence a 1.5 MG conventional type filtration plant connecting to a 4.5 MG reinforced concrete reservoir was constructed at Barrio Tisa.

The water supply from the dam for a while met the requirements of the Municipality of Cebu's population of 55,000. But some 20 years later as the population of the municipality of Cebu increased the Buhisan Dam source had became insufficient, more unfortunately so that the dam source was very effective only during rainy months, but during the summer season it was practically nil. This siutation spurred the municipal government of Cebu to tap the Hagubiao Spring located at the boundary of the municipality of Mandaue and the municipality of Consolacion some 11 kilometers to the north.

An intake tank 9.0 m diameter and 2.0 m deep, concrete reinforced, was constructed covering the natural spring. Four pumping units each having a capacity of 1,000 gpm were installed. Two of the 4 units were operated 24 hours a day at a time and the other two units served as standby for immediate take over in case of breakdown. From the two sources the municipality of Cebu was able to collect a total of 4,380,000 gallons of water daily. This volume of water even with some 40% losses was deemed enough to serve 70% of the water needs of 112,000 population of the municipality of Cebu at the time. The water sufficiency again lasted until the Japanese occupation.

During the dark years of Japanese occupation the Buhisan water shed area was neglected. People wantonly cut the trees and used the area as temporary "caingin." During rainy months practically great amount of soil was carried by the rain. The soil or mud settled in the dam basin reducing the dam's impounding capacity from the original 308,000,000 gallons to 56,000,000 gallons. During the post war period the dam started to dry up intermittently, nevertheless the operation had to resume. At this instance the Osmeña Waterworks System could no longer supply the water needs of the inhabitants. Private owned wells were dug here and there within the service area to augment the insufficient supply.

By the year 1957, Cebu already a city, suffered gravely from an acute shortage of water. The City Government had to construct 10 deep wells equipped with turbine pumps with diesel engines as prime movers. All the wells were operated 24 hours a day and the Osmeña Waterworks System was able to generate a supply of 3,628,800 gallons per day thereby making a total of 6,508,800 gallons per day from the combined sources. The total supply was able only to support about 60% of the total water needs of the city's population, which had already increased to 250,000 more or less. From the foregoing, although the supply was hiked to 4.0 MGD, yet it did not meet the water requirements of the population for domestic, commercial and industrial uses.

Additional Improvement to Cope with Growing Population

Timed with the Fourth Centennial Christianization of the Philippines, a historic religious event held in Cebu City in April, 1965, the City Government of Cebu appropriated P450,000.00 to finance the drilling of 15 additional artesian wells. These additional 15 artesian wells after completion had a rated capacity of 4,280 gpm although the actual discharge was only 3,000 gpm because some pumps had only a performance of 70%. As a result the total water supply was increased as follows:

a. Original Buhisan and Hagubiao Springs	1,440,000 GD
b. From First 10 Artesian Wells	3,628,000 GD
c. From Additional 15 Artesian Wells	4,320,000 GD
T O T A L	9,388,000 GD

Considering that according to the Census and Statistics figures Cebu City population has almost risen to 300,000 in the year 1965, the total water supply during the same year was barely adequate even disregarding water losses. However, while the preceding figure of 9,388,000 GD was the total water supply only about 4,500,000 GD were reflected in the gross billing and collection receipts. The reasons were attributed to the following:

a. Leakages in the old pipeline.
b. Free water granted to some indigent areas plus Truck delivering water to places where there were no distribution lines installed.
c. Defective water meters and unmetered service connections.
d. Illegal connections and pilferage.

From the above attending circumstances, Cebu City suffered continuously acute water shortage. It was on the basis of the above situation that by the year 1972 during the incumbency of Mayor Sergio Osmeña, Jr. that he contemplated to entrust the OWS operation and management to a private entity. This did not materialize, however, instead the diesel engines prime movers were changed to submersible pumps.

OWS Organization and Fiscal Administration

The organizational set-up of the OWS was a simple one. It was headed by a Manager and assisted by two Assistant Managers. One for Operation and one for Production. It had 5 divisions and 15 sections. The system had no sound personnel program that was responsive to the needs of management and employees. The employees were not fittingly placed in their proper assignments. There was no "on-the-job" training or retraining of the employees. The working condition was not ideal to motivate them in their work and in increasing their output.

The financial position of the OWS was characterized by yearly overdrafts. In fact, the yearly deficits during the last 5 years before the MCWD take-over averaged more than half a million pesos as shown below where the relationship between income and expenditures are illustrated:

Fiscal Year	Revenues	Expenditures	Overdrafts
1969 – 70	P 1,117,485.36	P 1,421,425.25	(P 303,939.89)
1970 – 71	1,132,667.34	1,761,151.25	(628,483.91)
1971 – 72	1,164,558.32	2,005,760.25	(841,201.93)
1972 – 73	1,559,243.82	2,118,850.52	(559,606.70)
1973 – 74	2,154,742.88	2,611,056.31	(456,313.43)

This was due to the fact that the yearly budgetary figures were not realistic. The yearly budgets were not regarded as projected inflow and outflow of funds, but merely a sort of specific plan of administration. No periodic operational reports were made, such as monthly or quarterly, for management guidance in whatever deficiencies and excesses in the operation, so management could immediately do something about it. Consequently, the reason or reasons for the wide imbalance between the income and expenditure were never made. Customarily, however, for Municipal, City, or Provincial water systems, the deficits were immediately covered from the General Fund. Inasmuch as the OWS water fee collection were turned over to the City Treasurer the yearly overdrafts were covered by the City's General Fund.

The Start of MCWD Operation

On February 1, 1975, the Metropolitan Cebu Water District by authority of Cebu City Council Resolution No. 873 which was subsequently adopted by the City Council Resolutions of Mandaue City, Lapulapu City and by the Municipal Councils of Liloan, Consolacion and Compostela acquired ownership, management and control of the different water systems of the aforesaid cities and municipalities.

February 1, 1975 will long be remembered by many Cebuanos and will be cherished by every MCWD employee as the historic day when a few pioneering men at the top of the Metropolitan Cebu Water District organization who with the modest sum of P200,000.00 borrowed from the City Government of Cebu as MCWD's operating capital, unmindful and unheeding all pronouncements that MCWD was bound to fail, steered the water district until it became what it is now today almost seven years later.

MCWD Organization and Management

A five member Board of Directors serve as the policy determining body of the district. Each of the member represent a segment of the society – religion, civic organization, professionals, women's club and education. Under the board is a General Manager assisted by five Division Managers – the Administrative Manager, the Chief Engineer, the Commercial Manager, the Production Manager and Installation and Maintenance Manager. Each division manager has its own specific function to perform which is contributory to the aim of the water district. Each division likewise is composed of enough number of sections to carry the details of the divisional requirements.

It was under this new management that the services of Camp Dresser & McKee International, a consulting Environmental Engineers, through LWUA was engaged to conduct a feasibility study on ground water supply for MCWD. The management also required CDM to recommend the following: (a) early action works (b) interim improvements (c) long range program (d) to provide the analysis and the support information for the extensive improvements of the district.

After the CDM report was submitted to LWUA for review field appraisals were conducted by both LWUA and ADB people in August and in October, 1975 to review the possibility and cost to upgrade the Metropolitan Cebu Water District's water supply. The field appraisals resulted in the signing of a memorandum of agreement drawn between MCWD represented by Engr. Oscar Jereza, Sr., Board Chairman and ADB represented by Gerharld Kahi for an initial loan of P58.07 M to finance (a) Early Action Works, (b) Interim Improvements, and (c) Consultants Services.

The Metropolitan Cebu Water District on May 31, 1976 engaged the services of Kampsax-Kruger International, consulting engineers, for the implementation of the CDM feasibility studies. The main work of KK/LI was the following:

a. Review of the CDM report.
b. Collect more detailed supplemental data to be used in the design.
c. Evaluate the ground water development.
d. Conduct topographic survey and mapping for reservoir sites, treatment plant and other structures.
e. Profiling and differential levelling for vertical control of all transmission and distribution mains.
f. Hydrogeological and hydrological investigations.
g. Program development leak detection and metering.
h. Related training of MCWD staff.
i. Improvement and design of pump stations.
j. Pipe cleaning and lining, and
k. Investigation and design of the Lusaran Dam.

The result of the KK/LI investigation indicated a greater potential for ground water development. As a result the term of agreement for consultancy was extended until December 31, 1981. MCWD contracted another P42 M additional loan from ADB through LWUA making a total laon of P100 M.

MCWD Plan of Expansion

The Metropolitan Cebu Water District, like any other water district, has its own plan of expansion; it will depend, however, upon the right existing financial conditions. Right now there is a resolution of the Municipal Council of Cordova, a municipality 7 kilometers from Lapulapu City in the island of Mactan, stating its willingness to join MCWD.

The Municipality of Talisay where the reservoir of Mananga is located, although at first showed opposition to join, yet a majority of its residents of Tabunok are already connected to MCWD. It is only a matter of time until Talisay will officially join MCWD.

The Municipality of Minglanilla next town to

Talisay towards the south is said to be willing to join the district. One important aspect the municipality of Minglanilla is its big potential for ground water.

The next municipality to Mingalanilla still further towards the south is the town of Naga. This municipality is the last of the municipalities included in the Metro Cebu Area.

MCWD Market and Marketing Aspect

The Marketing of Services involving prime necessities of life like water do not involve some special channel of distribution to reach the market. It only requires the identification of where the market exists, how large is the market, and what are the prospects for expansion. It further requires capital investments to be able to build the distribution piping system to reach the market.

After a series of market surveys conducted in the MCWD service area the result was very encouraging. In Cebu City, Mandaue City, Lapulapu City and environs there are districts or barangays where no water distribution lines exist. These districts are potential areas for additional consumers for MCWD. In fact the market estimates that if additional distribution lines could be installed in these areas by the year 1985, the projected number of concessionaires, aside from the present 16,500, could come up to about 35,000 consumers easily, instead of 27,000 to 28,500 as originally projected. The percentage of population served could also easily reach between 60 to 70 per cent. The Metropolitan Cebu Water District need not look elsewhere for new areas to serve in order to get more concessionaires. It needs only to expand its distribution net work.

Future Plans of MCWD

Aside from the pursuance of the Lusaran Dam Project, MCWD would be borrowing additional P100 M or more to strengthen its present distribution net work. It plans to construct three more reservoirs within the Metro Cebu Area in support of the growing needs of the increasing population of Metro Cebu. These are the new challenges that lay ahead. It is also the growing responsibility of the district towards the expanding communities under its jurisdiction.

Conclusion

There seems to be no end to what MCWD might plan and do in its great involvement in the development of its water supply system, as it accepted its great social responsibility of providing potable and sufficient water for the Metro Cebu Community. This statement is based on the fact that MCWD started from a very humble and lowly beginning and judging from what MCWD is now today after less than a decade of existence and on what it plans to do – the march is on.

"A CASE STUDY: METRO CEBU DEVELOPMENT PROJECT" PART 2 – THE INTERIM AND LONG TERM IMPROVEMENTS OF METRO CEBU WATER DISTRICT"

By G. STUART MENZIES

Project Manager
Kampsax Kruger Lahmeyer International

1.0 INTRODUCTION

This is the second of four papers forming a case study of a large provincial city water supply system in the Philippines. The first paper presented by the General Manager of Metropolitan Cebu Water District describes the earlier water supply developments for Cebu and the organization of the water authorities. This paper describes the studies carried out from 1976 to 1980, the design and construction work for interim improvements to meet demand up to 1982 and the general outline of plans for expansion of the system to meet demand up to the year 2000. The following two papers will describe technical details of the water resources of the study area, namely the surface water investigations and design for long term water supply, and the investigations and the development of groundwater resources which will supply needs up to the late 1980's.

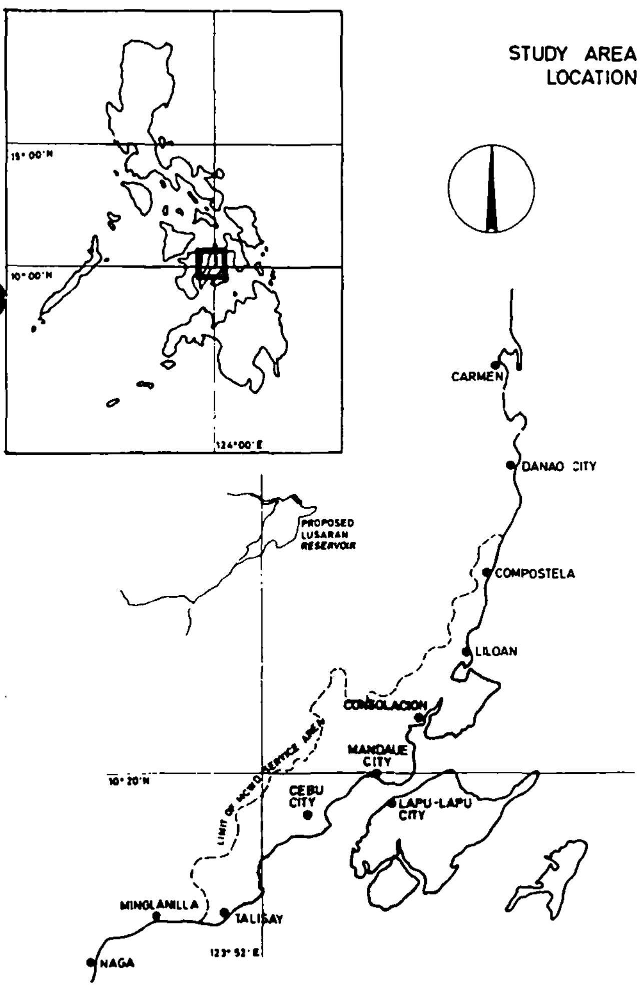


figure 1

2.0 THE SERVICE AREA

2.1 *Description*

The Metropolitan Cebu Water District (MCWD) currently incorporates the cities of Cebu, Mandaue and Lapu-Lapu plus the municipalities of Consolacion, Liloan and Compostela. For the purpose of the study, the municipalities of Cordova, on Mactan Island, and Talisay, on the southwest border of the MCWD, have been included, since it is anticipated that these areas will be supplied with water from the MCWD system.

The "service area" indicated in Figure 1 represents the sections of the study area which are currently served, or intended to be served, by the municipal water system. The area covers 180 sq. km and extends 30 km along the coast of the island of Cebu. Within the MCWD, Cebu City has the greatest population concentration (408,-000 in 1975) and ranks as the Philippines' second largest city. It fulfills the twin roles as the provincial capital of Cebu Island and commercial

*Project Manager of Kampsax Kruger Lahmeyer International, Consulting Engineers to the Local Water Utilities Administration for the Metropolitan Cebu Water District project.

centre of the Visayas Region (Region 7). Industry has become the major economic activity in the cities of Cebu, Mandaue and Lapu-Lapu and the municipality of Liloan, while agriculture remains predominant in Consolacion, Compostela and Talisay. Cebu also derives income from the tourist trade, attracted by the historical monuments and recreational opportunities.

2.2 *Population projections*

According to the latest population census, the total population in the study area was 694,000 in 1975, with Cebu City accounting for 59% of the total. By 1990 the population is expected to rise to one million and by 2000 one and a quarter million. The area served by the MCWD is limited to urban areas or barangays, with population densities exceeding 5 persons per hectare. By this definition, some 83% of the total population or 575,200 persons were living in the MCWD service area in 1975. Table 1 below provides a breakdown of population by municipalities in the service area.

Figure 2 indicates the projected population within the MCWD service area. The report has adopted NEDA's more conservative estimates (1977), using the assumed growth rate of 3.1% for the period 1980-1990 and 2.8% for 1991-2000. NEDA have recently revised their estimates, assuming growth rates of 3.4% and 3.2% for the respective time periods as shown in Figure 2.

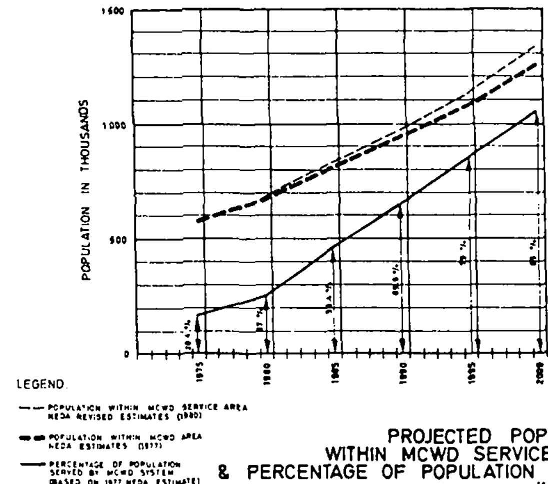
2.3 *Percentage of population served*

Reference to Table 2 and Figure 2 indicates that in 1975, less than 29% of the population within the MCWD service area were actually supplied with reticulated water. This proportion is expected to increase to 40% in 1981, nearly 70% in 1990 and 85% by the year 2000. This means that the population served by MCWD should reach 650,000 in 1990 and 1.05 million in the year 2000.

TABLE 1 POPULATION WITHIN MCWD SERVICE AREA (1975)

AREA	1975 POPULATION (000)	POPULATION WITHIN SERVICE AREA	
		(000)	PERCENT OF TOTAL
Cebu City	408.3	343.2	84
Mandaue	75.7	65.6	87
Lapu-lapu	79.2	63.8	81
Consolacion	19.7	13.5	69
Liloan	26.5	19.8	75
Compostela	15.0	6.3	42
Talisay (+)	55.2	48.9	89
Cordova	14.6	14.1	97
Study Area	694.2	575.2	83

Source: NCSO, Population Census 1975
(+) Not within MCWD at present



PROJECTED POPULATION WITHIN MCWD SERVICE AREA & PERCENTAGE OF POPULATION SERVED (1975-2000)

figure 2

3.0 WATER DEMAND

3.1 *Limitations on projections*

The water demand projections are based on the best available data and are subject to some uncertainty due to the following:

o Lack of reliable data for projection of domestic per capita consumption. For example,

- no detailed reliable studies had been conducted within the Philippines to determine the relative effects of increases in real incomes, or increases in water tariffs upon per capita consumption;
- no data for domestic consumption per capita are available for conditions directly comparable to those in the urban areas of Metro Cebu and which have 24 hours water supply.
- The assumptions pertaining to per capita consumption should be reviewed and projections updated as such relevant information comes to hand. There is an urgent need to institute studies to obtain data for more accurate projections.

o Wide variations exist in the water requirements of different types of industrial and commercial enterprises and may affect water demand projections for this sector significantly. NEDA have drawn attention to the fact that industrial expansion in the area is being constrained by uncertainties regarding adequacy of water supplies after the mid-1980s.

o The actual population served may fall below that projected if slippages were to occur in the MCWD development program – e.g., in groundwater and surface water production, extension of the distribution system (including the rate of service connections) and the reduction of unaccounted – for water loss (including leakages, illegal connections and illegal reconnections).

3.2. *Water Demand and Required water production*

It is anticipated that by the year 2000, water production will need to be six times higher than in 1980 in order to meet the projected Average Daily Demand – i.e., and increase from 41,400 cubic metres per day (cu.m./day) in 1980 to 266,600 cu.m./day in year 2000.

The production capacity of the water supply systems will reach 320,000 cu.m./day in the year 2000, sufficient to meet Maximum Daily Demand, which is assumed to be 1.2 times Average Daily Demand. This means a substantial development requirement when compared with the 1980 production capacity of only 49,700 cu.m./day. The efficiency of the water supply system has been greatly improved by metering and the leakage detection and control programs which have helped reduce water loss from an estimated 69% in 1975 to an estimated 25% in 1979. After commissioning of the Interim Improvements, the increase in pressure on the old pipelines, will initially increase water losses. However, it is assumed that water losses will decrease to 22% during 1980 and 18% in 1982 and ensuing years as the pipeline network is improved.

Note:

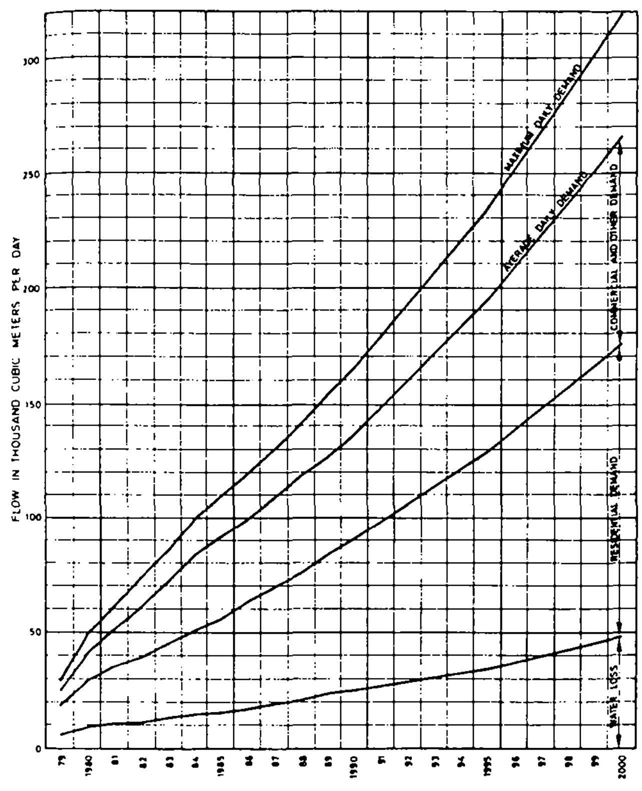
After partial commissioning of the Interim Improvements in early 1980, the increased system pressure and supply resulted in the actual water losses rising up to 40%. Losses have currently been reduced to about 32%. MCWD staff have been given further training in leak detection and a strengthening of organization and staff build-up for leak detection and illegal connection detection. The losses in revenue are serious, amounting to several hundred thousand Pesos per month.

TABLE 2 MCWD WATER DEMAND PROJECTIONS (1980-2000)

	1975	1980	1985	1990	1995	2000
Population in MCWD service area ('000)	575.2	684.8	800.9	936.6	1075.4	1234.7
Percentage of Population served	28.4	37.0	56.4	69.5	79.0	85.0
Consumption ('000 cu.m./day) Residential	NA[1]	20.6	41.0	65.6	94.4	128.4
Commercial and other[2]	NA	11.7	33.7	47.5	65.5	89.9
Total Daily Consumption	NA	32.3	74.7	113.1	159.9	218.6
Water Loss ('000 cu.m./day)[3]	NA	9.1	16.4	24.8	35.1	48.0
Average Daily Demand ('000 cu.m./day)[4]	NA	41.4	91.1	137.9	195.0	266.6
Maximum Daily Demand ('000 cu.m./day)[5]	NA	49.7	109.3	165.5	234.0	319.9

NOTES:

1. N.A. = Data Not Available
2. "Commercial and Other" includes governmental users, commercial, shipping and wholesale users.
3. Water Loss = unaccounted-for water lost through leakages or illegal connections.
4. Average Daily Demand = Sum of Total Daily Consumption plus Water Loss = Required Average Daily Water Production
5. Maximum Daily Demand = Average Daily Demand times 1.2 = Required Production Capacity of the supply system



MCWD WATER DEMAND PROJECTIONS (1980 - 2000)

figure 3

4.0 INVESTIGATIONS, DESIGN AND IMPLEMENTATION

4.1 *Objectives*

The objectives of the engineering services 1976-1980.

o To establish programes for solution of MCWD's problems of unsatisfactory water quality, water shortages, and inadequate service.

o Conduct necessary investigations for long-range planning and development of available water resources and the associated distribution system.

o Initiate improvements to the engineering and maintenance procedures and provide related training for LWUA and MCWD staff.

4.2 *Water Resources/Demand*

By the definition adopted in this report, the water supply developments for the Interim Improvements phase are those required to meet maximum daily demand in the MCWD service area up to the year 1982 – i.e., 73,000 cu.m./day.

4.3 *Surface Water Resources*

Earlier proposals presented in the Feasibility Study (1976) to start development of surface water resources have not been found necessary during this period 1976-1982, since groundwater resources have been found sufficient to meet demand for some years ahead.

However, during the period 1976-1977 the Consultants have completed the preliminary investigations for the surface water development, which is shceduled for Program 2.

Separate technical reports have been prepared and submitted for:

o Installation of hydro-meteorological equipment in the Balamban, Mananga and Kotkot catchment areas (October 1976)

o Verification Report (November 1976)

o Hydrology and water resources for the study area and Lusaran dam site (1977)

o Geological report on the Lusaran dam site, reservoir and transmission tunnel (August 1977)

o Geodetic survey report (May 1977)

o Engineering report on design of Lusaran dam and appurtenant structures – related work which has been completed includes the contract documents, specifications and bills of quantity for the dam, diversion works, spillway including stilling basin, raw water intake, transmission tunnel and transition structure (1977-1978)

o Inception report, and contract documents for the design of the Talamban-Lusaran permanent access road (August 1977)

o Population and Agriculture in the Lusaran (Cebu) Watershed:

A demographic and economic inventory (May 1977)

o Master plan for reforestation of the Lusaran dam catchment and resettlement of population within the catchment area (September 1977)

Recommendations have been made by the Consultants for the location and height of the dam, storage volume, erosion control and resettlement requirements in the catchment, engineering design of the dam and appurtenant structures, transmission tunnel and pipeline. Related cost estimates have been derived. The Consultants prepared the necessary investigation contracts and supervised the contractors during the investigations.

Following the Consultants' recommendation in 1977, LWUA and NEDA obtained a Presidential Order establishing an Inter-Agency Committee to assist MCWD in co-ordination with government departments and Agencies with respect to resettlement plans in the Lusaran catchment. A population census was made in 1977, and a survey of the catchment boundaries undertaken in 1979. A draft Presidential Proclamation has been prepared in late 1979 by the National Economic & Development Authority (NEDA) for establishment of Lusaran dam catchment area and its reservation in favour of the MCWD.

4.4 *Groundwater Resources*

Investigations:

Investigations indicated a greater potential for groundwater development than originally envisaged by the 1976 Feasibility Study. The original Terms of Reference were consequently expanded to include:

o Additional drilling and testing of exploratory wells to enable a more accurate quantitive assessment of groundwater potential.

o Development of groundwater in the Talamban and Consolacion areas to the north of Cebu City. The original Terms of Reference had specified groundwater development mainly in the Pardo-Mananga areas to the south.

o Well surveys in MCWD and Talisay area during 1976-78 to identify the location, number, size, depth, withdrawal rate and users of all existing wells. A total of 14,000 wells a were identified.

o Pumping test investigations for the old, existing MCWD wells (1976) and for the new exploratory and production wells (1977 to 1979). Tests indicated a far superior performance for the new wells.

o Drilling program undertaken between 1977 and 1979 to determine potential for groundwater development and establish production well-fields. Exploratory drilling operations were directed towards the largely untapped northern areas of Talamban, Consolacion, Liloan and Compostela, with additional drilling in the Talisay area to the south. A total of 42 wells were drilled in the program, 20 wells being later found suitable as production wells.

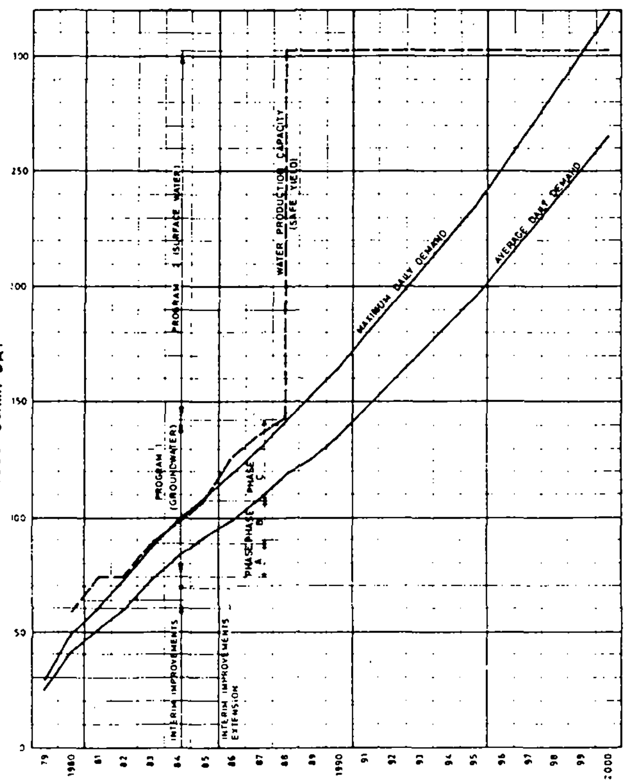
o Continuous monitoring of water level of 64 selected wells was conducted between 1976 and 1979 to provide basic information on water level fluctuations relative to aquifer recharge and discharge. (Continued monitoring is strongly recommended.)

Development:

The above investigations provided necessary information on the location and nature of aquifers, aquifer yield, water quality and groundwater management requirements.

Proceeding from the investigations, 4 new well-fields utilizing 18 production wells, were established by the end of 1979 in Mananga, Talamban, Consolacion and Compostela areas. The new well-fields are able to provide approximately 42,000 cu.m./day during a 20-hour pumping period. This, together with part of the existing MWCD withdrawal of 17,400 cu.m./day from its old well, should cover maximum daily demand within the service area until mid-1981.

To meet maximum daily demand projected for 1982 – 73,000 cu.m./day – an additional 5 wells will be required (one at Mananga and two each in Talamban and Consolacion well-fields.). Drilling, to complete the Interim Improvements, is scheduled to be completed in 1981.



MCWD WATER SUPPLY DEVELOPMENT (1979-2000)

figure 4

5.0 INTERIM IMPROVEMENTS PROGRAM

5.1 *Production and Distribution System*

For the MCWD's distribution system, the objectives of the Interim Improvements phase are to increase the production capacity, provide a reliable service to a larger proportion of the population, augment the clear water storage volume, strengthen the capacity of the transmission and distribution facilities and improve the auxiliary service facilities.

5.2 *Distribution System Studies*

First the water demand projections per capita were determined. After that each municipality was divided into 3 land use areas: residential, commercial, and industrial. Each land use area again was divided into 3 zones with different population density.

The distribution system consists of three separate systems:

1) Low level zone, below 50 above MSL.
2) High level zone in Lahug, 50-90m above MSL
3) High level zone in Guadalupe, 50-90m above MSL.

5.3 *EDP – Programme*

The program was used to determine the pipe flow and pressures in the distribution system, for a given set of water demands, (Peak hour, min. hour and fireflow) supply rates, and storage tank water levels imposed on a pipe network. The friction losses in the pipelines are calculated by means of the Hazen-William Formula. Data preparation is simple. It is not necessary to estimate flow in pipelines nor is it necessary to define loops.

This program makes it possible to remove or add portions to the systems without affecting the existing data.

5.4 *Development*

Implementation of the Interim Improvements to the distribution system commenced in late 1977, with completion now expected in 1982. The development during this phase is aimed at providing production capacity capable of meeting the maximum daily demand in 1982 – i.e. 73,000 cu.m./day.

Briefly, the Interim Improvements to the distribution system consist of:

o Four well field areas were identified, each group of wells delivering into a storage tank with a chlorination unit. From each tank the treated water flow by gravity by transmission mains to the distribution system.

o Construction of groundwater production, chlorination treatment unit and clear water storage facilities at Mananga, Talamban, Consolacion and Compostela. The three 5,000 cu.m. clear water storage tanks at Mananga, Talamban and Consolacion increased the MWCD's existing storage capacity at Tisa (15,000 cu.m.) to a total of 30,000 cu.m., sufficient to meet the 1982 demand.

o Cleaning and lining of 15km of existing distribution mains of dimensions 350mm and 400mm.

o Laying of about 100km of new transmission and distribution mains with diameters ranging from 700mm down to 100mm.

o Construction of four pressure reducing stations on the distribution mains from Mananga, Tisa, Talamban and Consolacion, with the aim of protecting the old distribution system of Cebu against the high pressure of the new system.

o Minor improvements to the old treatment plant at Tisa – improvements have been confined mainly to the chemical dosage and mixing systems, since the plant is scheduled to be phased out by the end of 1982.

The Hagubiao spring and pumping station (capacity 5,000 cu.m./day) will be phased out during the Interim Improvements because of its frequently poor water quality, declining yield, and unreliability.

5.5 *Operation and Maintenance*

A marked improvement in MCWD's technical service level has been accomplished by a well equipped general workshop, water meter repair shop, stockyard, vehicle maintenance shop and laboratory at Talamban. The workshop is equipped with facilities required for the maintenance of the developed MCWD system. Leakage detection surveys have been undertaken in 1977 by the Consultants and continued in 1979/80 by MCWD with implementation of control measures. Illegal connections have been investigated and the aim of universal metering of service connections within MCWD had almost been met by early 1980. However, further measures are required within the Interim Improvements phase to bring the operation and maintenance of the system to a suitable standard.

5.6 *Training*

During the Interim Improvements phase, over 80 MCWD and LWUA personnel received on-the-job training from the Consultants in investigations, construction supervision and operations and maintenance.

LWUA professional staff were trained in geodetic surveying, well-drilling supervision and commissioning of electrical/mechanical plant during the period 1977 to 1980.

Training for MWCD staff covered the following areas, with numbers of trainees shown in brackets.

Investigations

- o Geodetic and topographic surveying (6)
- o Leakage detection in distribution mains (12) Training was carried out in 1977 and in 1980.
- o Groundwater – data collection and processing, pumping tests, waterlevel monitoring (6)

Supervision

o Daily supervision of drilling and well construction and administration of contracts (6)

o Training of construction inspectors, including both classroom and field instruction in pipe-laying; earthworks, reinforced concrete structures; pump and water-meter installation and testing; installation of electrical and mechanical controls in pumpstations and chlorination buildings; public safety and convenience. LWUA's training manual for construction inspectors provided a sound basis for the training program (17 persons).

o Field visits to LWUA projects in Davao City, Batangas City, Tacloban City, and Cagayan de Oro by groups of 3 to 7 MCWD staff.

Operation and Maintenance

o Groundwater – operation and maintenance of pumping test equipment; use of TV camera equipment for inspection of well casings and screens (6)

o Distribution system – intensive 6-month training program including classroom tuition, field inspections and workshop demonstrations(6). As an adjunct to this training program, the consultants produced a detailed Operations and Maintenance Manual.

Overseas Study

During 1978, three Department Heads of MCWD undertook study tours of three months duration to examine the administration and operations of water authorities in Australia, New Zealand and Singapore. The MCWD's Water Quality Control Chemist spent more than two months with the Consultants in Denmark studying laboratory and waterworks operations. General administration of waterworks was studied by the General Manager in two-month tour to Germany and Denmark. (5)

Design and Drafting

o Training in engineering design and drafting practice (20¼)

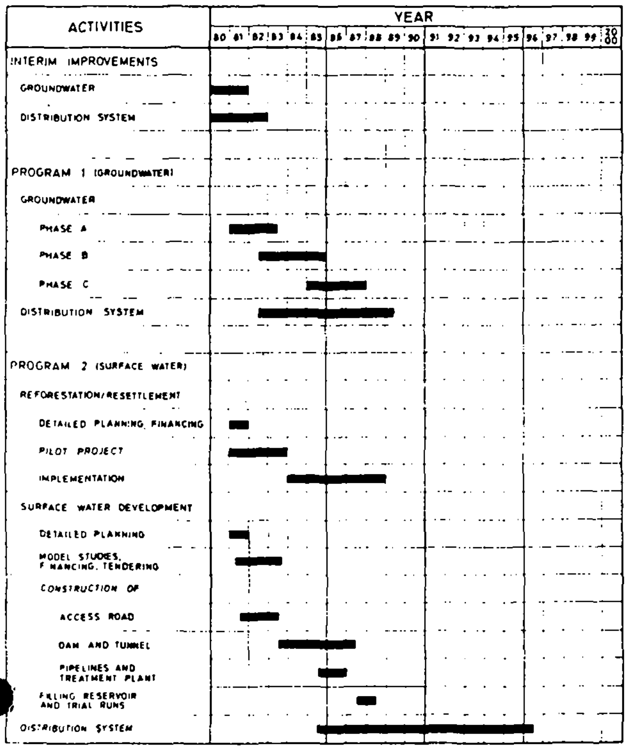
Additional Training

Further training of MCWD personnel has been recommended to enable the Water District staff to reach the required efficiency for greater responsibilities in the future.

6.0 **PROGRAM I DEVELOPMENT** (1982-1988)

6.1 *Objective*

The objective of Program I Development is to cater for maximum daily demand within the MCWD service area up to the year 1988. This will require a production capacity of 142,000 cu.m./day sufficient to serve a population of 572,000 persons, i.e. 65% of the total population within the MCWD service area plus industrial and commercial demand.



SCHEDULE FOR DEVELOPMENT OF MCWD
WATER SUPPLY SYSTEM (1980-2000)

figure 5

6.2 *Surface Water*

Surface water resources will not be utilized during this development phase, since groundwater development to full potential within MCWD will meet demand to 1988 and requires substantially less capital investment.

However in 1982 it will be necessary to start resettlement and reforestation of the catchment. Also initial planning and special studies must be started early enough for construction 1984-88 of the Lusaran dam, transmission tunnel and pipelines, and the treatment plant.

6.3 *Groundwater*

During 1982-1988 period, groundwater development will almost double, rising from 73,000 cu.m./day to cover the 1988 demand of 142,000 cu.m./day. This latter production figure represents the safe yield of the identified aquifers. Additional withdrawal of groundwater would result in groundwater mining and increased saltwater intrusion, adversely affecting both quantity and quality of available groundwater.

During Program I, groundwater development is scheduled to proceed in 8 additional well-field areas. Development will be in three phases:

- Phase A (1982-83) – 30,000 cu.m./day
  (*reduced by phasing out production of old well)
- Phase B (1983-85 – 20,000 cu.m./day
- Phase C (1985-88) – 32,000 cu.m./day

6.4 *Production and Distribution System*

The improvements scheduled for Program I will provide production capacity and the distribution system adequate to meet the maximum daily demand to the end of 1988. works proposed are:

o Groundwater production and treatment facilities at the new well-fields.

o Construction of 6 additional service tanks of 5,000 cu.m. capacity each at Tisa, Talamban, Mananga, San Vicente (2 tanks) and Cabadiangan (Kotkot); a 4,000 cu.m. water tower at Lapu-lapu and two 2,000 cu.m. tanks at both Lahug and Guadalupe. The storage capacity developed in Program I will be 42,000 cu.m. The MCWD's total storage capacity will then be 57,000 cu.m.,* sufficient to cover demand to the year 1988.

o Reinforcement and extension of the distribution network with approximately 100km of pipelines ranging in diameter from 100mm to 90mm, as shown in Figure 12.

The extended service area is divided into two pressures zones – i.e. the Low Level Zone, serving elevations between 0 and 50 metres and the High Level Zone serving elevations between 50m and 90m. The Low Level Zone occupies about 94% of the total service area and the High Level Zone the remaining 6%.

Water supply for the two High Level Zones will come from the Guadalupe and Lahug well-fields. Since expected yields from these well-fields (20,000 cu.m./day) will greatly exceed the projected maximum demand (about 6,000 cu.m./day by 1990), the surplus will be supplied to the Low Level Zone via balancing tanks with top water level of 70m above mean sea level.

*This figure takes into account the phasing out of Tisa treatment plant and its 15,000 cu.m. clear water tank after year 1982, (as this old tank is located at too high a level for the new Low-Level Zone)

7.0 **PROGRAM 2 DEVELOPMENT** (1989-2000)

7.1 *Objective*

The objective of Program 2 Development is to cater for maximum daily demand within the MCWD services area up to the year 2000, when an estimated maximum production capacity of 320,000 cu.m./day will be required. This would provide an adequate water-supply for 1.05 million persons – i.e. 85% of the projected population within the MCWD service area in the year 2000, as well as a large industrial and commercial demand.

7.2 *Surface Water*

The Lusaran reservoir is scheduled to come into operation in mid-1988, providing a safe yield equivalent to 160,000 cu.m./day.

Construction time for the approximately 100m high Lusaran dam and the 7.5km transmission tunnel is estimated to be 48 months with an additional 12 months required for filling of the reservoir commissioning tests and trial runs of the surface water supply scheme. Construction of the dam and transmission tunnel will therefore need to commence by mid-1983. Construction planning, model studies, financing, tendering and contract procedures are estimated to require 30 months and should therefore commence in 1981.

An important requirement of the surface water development will be erosion control in the catchment area of the Lusaran dam. A draft Presidential Proclamation has been completed by NEDA to reserve the catchment area in favour of the MCWD.

A comprehensive reforestation and resettlement project has been recommended to alleviate the problems of destruction of vegetation cover and subsequent soil erosion caused by current land was practices. According to preliminary cost-benefit analysis, the reforestation and resettlement scheme would be economically self-reliant given estimated revenues from selling timber and other products.

Construction of the 21km permanent access road to Lusaran should be commenced in 1982 to improve access to the reforestation and resettlement projects, provide adequate transportation of forest products, engineering construction materials, residents, and construction workers.

7.3 *Production and Distribution System*

The major development of the distribution system for the combined groundwater and surface water schemes in Program 2, will involve:

- Construction of a raw water treatment plant at Talamban, with maximum capacity of 200,-000 cu.m./day (rated capacity 160,000cu.m./day = the safe yield from Lusaran reservoir).
- Construction of a 40,000 cu.m. clear water tank in connection with the Talamban surface water treatment plant, 2,000 cu.m. water towers at Cordova and Maribago on Mactan Island and a 4,000 cu.m. water tower in Cebu City. This will bring the total clear water storage capacity for the MCWD system to 105,000 cu.m. which is sufficient to cover demand to the year 2000.
- Reinforcement and extension of the distribution network with about 170km of pipelines with diameters ranging from 100mm to 1,400mm. Major extensions of the network will supply Mactan Island, Talisay, Compostela and areas adjacent to Cebu City and Mandaue City.

8.0 COMBINED GROUNDWATER AND SURFACE WATER PRODUCTION

8.1 *General*

When the Lusaran reservoir comes into operation in the latter half of 1988, the MCWD will have surface water and groundwater resources giving a safe yeild of 302,000 cu.m./day. Early in Program 2, demand will be far less than the available water resources – e.g. 165,000 cu.m/day in 1990. The MCWD will consequently need to decide upon the proportions of surface water and groundwater to be utilized to meet demand. This decision will directly influence the design of the distribution system in Program 2.

Two of the many possible alternatives are shown in the table below:

8.2 *Alternative 1* – provides that both the new surface water production facilities and the groundwater production facilities developed in the previous stages are utilized to the same extent. Thus, on the commissioning of Program 2, both sources would be utilized to about 50% of their full capacity.

WATER PRODUCTION ALTERNATIVES FOR MCWD SYSTEM (1989. - 2000)

WATER SOURCE ('000 cu.m./day)	INTERIM IMPROVEMENTS & PROGRAM 1 DEVT	PROGRAM 2							
		ALTERNATIVE 1				ALTERNATIVE 2			
	1988	1989	1990	1995	2000	1989	1990	1995	2000
Groundwater	142.2	72.0	74.0	109.0	142.2	12.0	12.0	74.0	142.2
Surface Water	-	82.0	89.0	125.0	160.0	142.0	154.0	160.0	160.0
TOTAL:	142.2	154.0	166.0	234.0	302.2	154.0	166.0	234.0	302.2
Maximum Daily Demand	141.7	153.4	165.5	234.0	319.9	153.0	165.0	234.0	319.9

TABLE 3

8.3 *Alternative 2* – provides that only the surface water production facilities are utilized to the greatest possible extent – i.e. around 88% of supply capacity early in 1989, at the beginning of the stage, increasing to 100% utilization within the first five years of operation. Initially, the only groundwater production sources in operation under Alternative 2, would be in areas where the water pressure might otherwise be inadequate:

- Distant northern well-fields of Compostela and Mulao, providing a capacity equal to the demand of the local service areas of Liloan and Compostela.
- Well-fields of Lahug and Guadalupe, operating at a level equal only to the demand of the High Level Zone.

Under Alternative 2, total groundwater production on commissioning of Program 2 would amount to about 12,000 cu.m/day i.e. – meeting only 8% of demand. Further well-fields would be re-activated as required to meet maximum daily demand, as shown in Table 3.

Preliminary financial analysis indicates little difference in the relative attractiveness of the two alternatives. This implies a degree of flexibility in the operating mode for the combined surface water and groundwater schemes in Program 2. However, it is emphasized that a choice between these (or other) alternatives need not be made until 1987. The decision should be delayed until that time to take account of possible changes in forecast demand and costs, particularly electricity costs for groundwater pumping.

INVESTMENT PROGRAM

9.1 *Investment Schedule (1976-2000)*

The proposed investment schedule is shown in the figure below. The main features are noted below using 1979 price levels.

o Additional investment required for implementation of the Interim Improvements amounts to P35.5 million over and above the P100.2 million already committed.

o Program 1, involving development of groundwater to its full potential (142,200 cu.m./day) plus major development of the distribution system, will require an investment of P190 million (1979 price level).

o Program 2, which aims at a water production capacity to meet maximum daily demand for the MCWD service area until the year 2000, will require the following investment of P1130 million (1979 figures) for the Lusaran dam, transmission tunnel, transmission pipeline and the Talamban raw water treatment plant, and distribution system.

The reforestation and resettlement project P52 million at 1979 prices is not included as this is considered to be a self-financing project.

FINANCIAL PROJECTIONS

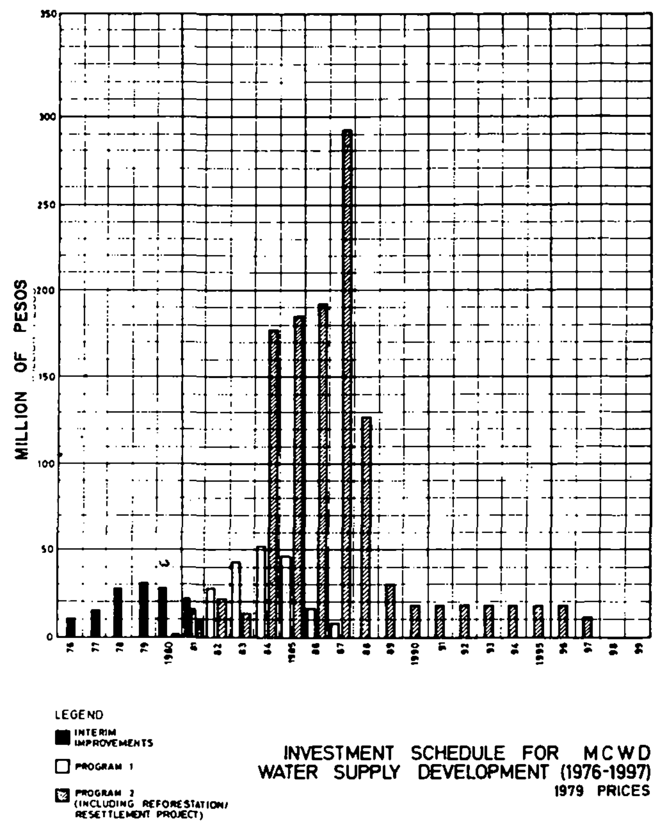
10.1 *Assumptions*

Projected financial statements for MCWD have been prepared for the years 1980 to 2000 based on the following assumptions:

o Water sales follow the demand and the actual supply capability is sufficient to meet this demand at all times.

o Water tariffs are set at a level adequate to meet operating and maintenance costs as well as debt service payments, and to provide a reasonable surplus for future replacement, extension and improvements to the supply system.

o All funds required in addition to the internal cash generation are financed by external loans carrying an interest rate of 9 percent per annum and repayment over 30 years starting the year after the completion of the project (stage).



INVESTMENT SCHEDULE FOR MCWD WATER SUPPLY DEVELOPMENT (1976-1997)
1979 PRICES

figure 6

10.2 *Loan Requirements*

An analysis of the development of the MCWD's financial position shows that in addition to progressive increases in the water tariff primarily to compensate for inflation it is necessary to obtain outside financing for the continued expansion of the water supply system to serve an increasing proportion of the population and industrial and commercial expansion.

The following loan requirements have been identified using current prices:

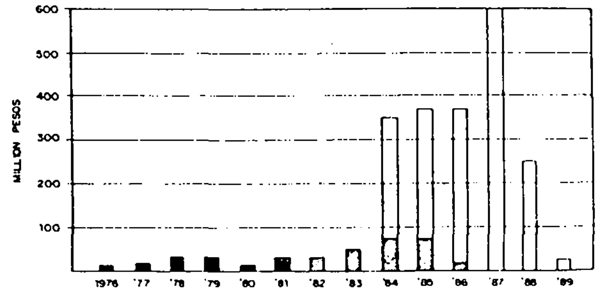
o An extension of the present LWUA loan of 100 million pesos by another 20 million pesos in 1980.

o A loan of 250 million pesos equal to 73.5 percent of the Program 1 Development, starting in 1981.

o A loan of 1800 million pesos equal to 77.7 percent of the Program 2 Development starting in 1984.

The remaining development costs until 1990, estimated to be 250 million pesos, as well as all costs from 1990 to 2000 are assumed to be financed from operations.

A summary of the scheduling of the load requirement until 1989 is shown graphically below:



SCHEDULE OF LOAN REQUIREMENTS (1976-1989)

LEGEND
INTERIM IMPROVEMENTS
PROGRAM 1 - GROUNDWATER
PROGRAM 2 - SURFACE WATER

figure 7

ACKNOWLEDGEMENTS

The Consultants, Kampsax Kruger Lahmeyer International and their Philippine associate firms, DCCD and EDCOP, extend their thanks to the LWUA and MCWD Boards, Members of the Technical and Administrative staff of LWUA and MCWD, the officials of government agencies and departments of the Republic of the Philippines, and private enterprises who participated in this project during the period 1976-1980.

Assistance by the University of San Carlos, Cebu, the International Agency Committee, and local government bodies, and the liaison with the Asian Development Bank was of significant value and much appreciated.

Finally, special commendation is due to the unflagging and devoted effort of the Philippine professional, technical and administration staff in the Project Team.

THE LUSARAN DAM PROJECT

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The Article discusses historic and current reasons for the design of a dam to augment the water supply of the Metropolitan Cebu Water District which at present, is essentially based on groundwater supply. Groundwater is limited and supplies from the dam are intended to cover medium to long range water demands. Upon a brief elaboration of the extensive investigation works and basic studies in various fields a short description of the project features is given.

A major part of the articles deals with the rehabilitation requirements of the catchment area where the present land use practice of shifting cultivation has resulted in the loss of about 90% of the original vegetative cover with severe soil loss due to extensive sheet and gully erosion.

To reduce soil erosion rates of more than 6000 m^3/km/year, a staged reforestation program was prepared for the larger part of the catchment area combined with the construction of bench terraces allowing for high intensity agriculture.

The slash and burn practices of the shifting cultivation can, however, only be stopped if the scattered population is entirely resettled at the ridges of the catchment area in village-like settlements.

The present combined concept of staged reforestation, high intensity agriculture and resettlement within the overall project offers a number of psychological, socio-economic, technical and financial advantages sofar not attained in similar projects in this country, the main points being.

Farmers will not be required to resettle outside the catchment area. The labor force of the catchment area will be fully absorbed even under long term considerations by provision of guaranteed employment in the reforestation scheme and related construction activities including the dam. Traditional subsistence income is improved by provision of 1.5 ha land on bench terraces and a house lot of 700 m^2 including a house.

The project thus does not only satisfy future water demands of the Water District but rises the income and thus the living standard of the population in the catchment area. Social unrest which may delay or complicate project implementation will practically be avoided.

THE LUSARAN DAM PROJECT

1. Introduction

The projected Lusaran Dam on the Island of Cebu will be the first major dam in the Philippines for the sole purpose of water supply. The project development is therefore followed up with great interest by the future beneficiaries and the authorities concerned.

The island of Cebu belonging to the major islands of the Philippine Archipelago is located in the center of the Visayan Island Group. The roughly 200 km long island is North-South oriented with an average width of about 25 km. From its western coast the island of Negros is visible and from the the eastern coast the island of Bohol can be seen.

The landscape is mountainous with a highest elevation fo some 990 m asl. The main rivers are the Balamban River, the Mananga River, the Kotkot and Sapangdako River and the Carcar River in the south.

The climate is basically maritime and tropical, characterized by temperatures ranging from 24 to 30°C and relative humidities ranging from 64 to 91%.

Seasonal climatic variations are not very distinct and precipitation is fairly distributed all year round. The mean annual precipitation is about 1900 mm which falls during a mean 172 rainy days, with only slight peaks during July and November. Cebu Island lies south of the typhoon belt and is thus not directly affected by typhoons.

The City of Cebu is the capital of the island and simultaneously the capital of the Visayan Region.

A view back into history: It was at Cebu in 1521 where the Spanish explorer Magallanes landed and where Christianity spread from this very place of all over the Philippines.

Cebu City or better known as Metropolitan Cebu, to include adjacent communities, is the second largest city of the Philippines and has about 600,000 inhabitants. The average past growth rate of the population was 3.1%, but the rate is presently increasing due to intensive development activities in the area.

2. THE PRE-LWUA WATER SITUATION IN METRO CEBU

Records show that the public water supply system has never been really satisfactory. This led in the past to private initiatives, such that families, houseowners and enterprises had their own wells dug, of course without any control of geohydrological considerations. A current survey without about 8000 privately owned wells of different depths, capacity, status and operational patterns.

The uncontrolled well construction and operations led-due to overpumping to a considerable lowering of the ground water table and saltwater intrusion in greater parts of the Service Area of the Metropolitan Cebu Water District, the organization now in charge of the water supply.

Although the water provided by this organization to the inhabitants of the service area is basically based on ground water supply provided by deepwells, there exists also a small surface water system, the 1.5 mill. gallon BUHISAN reservoir which, however, has now only a fraction of its original capacity, since the lake is entirely silted up as a consequence of forest denudation.

However, all the water available to this organization had been until recently insufficient and the distribution system poor, both in extent and maintenance status. Frequent power supply interruptions due to brownouts or power failures further aggravated the already deplorable water service in Metro Cebu.

Interestingly, people did not blame the Power Supply Company for its unstable power supply system, but blamed the Water District for not providing water and unreliable supply.

One should know, however, that the Water District's own pumps were directly connected to the distribution system. Storage facilities which would have helped to overcome at least the brownout interruptions were virtually not existing.

As regrettable as this was, the situation was simple: No Power, No Pumping, No Water. These frequent interruptions had another negative side effect: The distribution system due to its natural slope towards the coastline would drain partially towards the sea. When power was restored, the pumps delivered more water due to lack of head. Silt and fines were flushed from the deepwells into the distribution system. Each refilling of the system flushed away both these fines together with older deposits and scale, which ultimately clogged the few water meters. Due to lack of chlorination algae growths appeared at a great deal of the water-meters between the dial and the covering glass, making reliable reading impossible. All these facts were a substantial reason for the discrepancies between metered and actual consumption. In other words, losses in otherwise obtainable revenues were considerable, resulting in a permanent shortage of funds. The high age of part of the system, poor construction quality, insufficient funds for repair and maintenance resulted in additional leaking and more water loss and thus income losses.

3. Previous Water Resources Development Studies

It may have been in this light that the former Osmeña Water Works, the predecessor of the present Metropolitan Cebu Water District, may have thought of a more reliable and plentiful water supply system based on surface water with continuous gravity supply not only to make up for the supply deficiencies but also to cover the future growing demand.

During 1967 and 1968 limited investigations were performed for a dam to be constructed at the Balamban River near the Barrio Lusaran, some 15 km away from Cebu City. Even a feasibility report on the "Expansion of the Osmeña Water Works" was prepared in 1971, dealing with the Lusaran Dam as the main future water supply source.

While this first report would hardly meet today's standards of a feasibility, study the initiative and the basic approach in the design concept must still be considered remarkable.

In 1975 another feasibility study was prepared which arrived also to the conclusion that the Lusaran Dam should be the first to be developed from several investigated reservoir system combinations to cover the long term water demand for Metropolitan Cebu.

4. Recently Completed Studies

Only four years ago engineering works were taken up for the definite design of the Lusaran Dam Project, being part of a broader spectrum of engineering services which covered also ground-water investigations and improvements of the distribution system, these services being financed by an ADB Loan.

Remarkably, the Terms of Reference provided also for rehabilitation measures of the catchment area by requiring a Masterplan for Erosion

Control by Reforestation and the Preparation of a Resettlement Scheme for farmers living in the area. The inclusion of these aspects turned out only to be too necessary as will be outlined later.

Investigation work for the dam project starting in various sectors by August 1976 did not progress as originally scheduled since considerable gaps in the establishment of design input data had first to be filled: Maps of the area of appropriate scale and accuracy were virtually not existing. The few drilling cores from an earlier drilling program were no longer available and the borelogs were obviously severely misinterpreted. Hydrological data like precipitation and streamflow data were, with one exception (Lahug Airport), scattered, of short duration, limited in its interpretability, inconsistent and partly unusable. Going to and coming from the site was almost a full day's job.

Thus, all sector works had to start from scratch. Various survey and map production contracts had to be awarded; geotechnical investigation contracts included not only drilling works but also resistivity tests, micro seismic, dilatometer tests as well as lab tests on samples taken for soil mechanics investigations. The establishment of a hydrometric network was initiated, an access road to the site constructed and a filed camp erected.

5. The Dam Site And Reservoir Area

The first field reconnaissance undertaken upon a detailed study of aerial photos showed favorable morphological features: A steep sloped, narrow valley, allowing for a dam of more than 150 m height. Outcropping rock both at the valley and the left abutment revealed to be Andesite.

Geological findings as a result of detailed mapping and core-drilling yielded, however, a more complex picture: The andesite sequence being weathered and fractured, and at the right abutment overlain by an andesitic breccia in a fine tuff matrix, again overlain by slope debris of which currently a part had slidden down into the valley, quite close to the projected damsite. A fault, tightly filled with silty sand, was identified to cross diagonally the dam site. Water pressure tests in all boreholes along the dam axis showed Lugeon Values ranging from 0 to over 50, making the need for a grouting curtain evident.

These conditions ruled out the construction of a concrete arch dam, and even a buttress type gravity dam had to be discarded due to the non-uniform foundation conditions. Consequently, a rockfill dam with central impervious core was adopted for the design.

A part of the 2500 m core-drilling program did not refer to the damsite but to an 8 km long tunnel through which water from the Balamban watershed will be conducted towards Cebu City. The petrografic units encountered were even more different than at the damsite, ranging from massive siltstone with intercalated sandstone layers, andesite, calcareous sandstone and massive but partly cavernous limestone. High groundwater level, partly artesic, will pose some problems during tunnel excavation, but will also allow to gain additional groundwater as a gratis by-effect if the long tunnel is considered as a giant horizontal well.

The reservoir area can be considered tight as was concluded from careful regional geological mapping, spring mapping and yield observations. Groundwater measurements and some boreholes in the reservoir area supported this assumption.

In terms of seismology the Cebu Island can be considered as a more tranquil area with earthquake intensities ever measured not exceeding the value VI of the Rossi-Forel scale. Seismic active regions are at some distance from Cebu City; some 15 km off the west coast of Cebu Island and at the southern tip of the island of Bohol. An acceleration value of 0.1g was thus considered appropriate to be considered in all stability calculations whereas for the dam a value of 0.15 g was applied horizontally and 0.05 g vertically.

With respect to hydrological and water resources engineering studies a considerable part thereof had to be devoted to the collection and analysis of data relevant to the project. Statistical analysis, regional analysis and a storm rainfall – runoff model were used to derive flood hydrograph and the flood frequency relationship for the Lusaran Dam Site.

Subsequently, detailed reservoir operation studies were executed to derive the storage/yield reliability characteristics of the Balamban River at the Lusaran damsite. These studies utilized synthesized streamflow series permitting the reservoir performance to be characterized by the probability of meeting demand over a typical operation period for a range of target yields.

Basin erosion rates were computed using a soil loss equation together with data from the nearby Buhisan Reservoir. Sedimentation accumulation rates were computed for the reservoir in particular at various degrees of delivery depending on the deterioration of the present vegetation cover and increasing reforestation respectively, *indicating directly the need of a comprehensive* reforestation of the catchment area.

These and other investigations led to a design concept for a 100 m high rockfill dam, some technical data outlined below:

6. List of Technical Project Data

Hydrological Data

– Catchment area	: 6725 ha
– Mean annual streamflow	: 2.05 m^3/s
– Probable maximum flood (PMF, peak flow)	: 1360 m^3/s

Reservoir

- Highest water level at PMF : 232 m a.s.l.
- Maximum operational water level : 228.30 m a.s.l.
- Minimum operational water level : 163.35 m a.s.l.
- Deed storage volume : 10 x 10^6 cum
- Active storage volume : 116.4 x 10^6 cum

Dam

- Type : Rockfill dam with inner core
- Height above riverbed : 100 m
- Crest elevation : 235 m a.s.l.
- Crest width : 10 m
- Crest length : 315 m
- Free board : 3 m
- Upstream/Dowstream Slope : IV on 2H
- Total Dam Volume : 3,150 x 10^3 cum

Spillway Data

- Type : Through type intake with inclined tunnel
- Maximum spillway discharge : 1100 m^3/s
- Crest elevation : 228.30 m a.s.l.
- Crest length : 75.5 m
- Length of spillway tunnel : 506.66 m
- Tunnel diameter : 8.00 m
- Stilling basin length : 120 m

Diversion Works/Bottom Outlet

- Design flood peak : 400 m^3/s
- Outflow peak : 190 m^3/s
- Frequency : 10 years
- Reservoir rise : 15.77 m
- Storage increase : 4.2 x 10^6 cum
- Total Length of Diversion Tunnel : 740.20 m
- Length of Upstream part : 291.70 m
  and diameter : 4.50 m
- Length of downstream part : 448.50 m
  and diameter : 6.00 m
- Bottom outlet gate : 2.0 x 2.0 m
- Maximum discharge : 150 m^3/s

Cofferdam

- Upstream crest height above riverbed : 19 m incorporated in main dam
- Downstream cofferdam : not required

Raw Water Intake

- Type : inclined gallery
- No. of intakes : 5
- Elevation of intake No. I : 215.35 m a.s.l.
- Elevation of intake No. II : 202.35 m a.s.l.
- Elevation of intake No. III : 189.35 m a.s.l.
- Elevation of intake No. IV : 176.35 m a.s.l.
- Elevation of intake No. V : 163.35 m a.s.l.
- Continuous draft over entire lifetime at any elevation down to 164.00 m a.s.l. : 1,770 l/s
- Maximum draft : 10,400 l/s

Transmission Tunnel

- Tunnel length : 7527 m
- Tunnel profile : 1.60 x 2.70 m
- Maximum discharge capacity : 14,500 l/s

7. Features of the Proposed Dam

The selected rockfill embankment dam has a simple conservative cross section: with andesite shoulders, a symmetrically arranged central sandy-clay core with differently graded transition zones of river gravel. The rockfill shoulders have an outer slope of 1:2, which possibly could be made steeper if dynamic load tests simulating earthquake action, so permit. However, such tests have not yet been performed and could not be executed in the Philippines.

The core has slopes of 4:1 with a top width of 10 m and is founded on sound clean andesite rock. Rockfill and core are separated by fine and coarse graded transition zones. The downstreams transition zone is connected to a drainage blanket of 2 m thickness which separates the rockfill from the underlying river gravels.

The upstream slope is protected by a 1 m thick riprap layer and the downstream slope will receive a top soil layer with grass.

The upstream cofferdam is incorporated in the main dam, equally arranged with a central core of sandy silt material and andesite rockfill shoulders sloped 1:2. The cofferdam will be 19 m high providing protection during the construction period for the main dam against floods with a recurrent period of 10 years. A downstream cofferdam is not required.

The relatively steep sloped, narrow valley and downstream morphology at the left abutment favoured a tunnel type spillway concept instead of one of the open chute type. The spillway intake is a bath-tub like trough structure with fixed 75 m long sill arranged at the left abutment. No mechanical installations are foreseen to avoid operational and maintenance problems. From the spillway intake the waters are discharged via the spillway tunnel with inclined upper and flatter lower part, which is followed by a stilling basin where the energy of the spilling water jet, reaching velocities of more than 35 m/s will be dissipated.

The actual intake structure for Cebu's water supply is entirely separated from the dam and consists of an inclined accessible concrete gallery, housing the intake pipe with 5 intake valves uniformly distributed over the active storage head. The intake pipe enters the transition tunnel at the lower end of the intake structure. The tunnel is also accessible by the intake structure. The intake structure allows for the installation of a small hydroelectric power generation unit with a capacity of about 3000 kW.

Since water releases to the treatment plant will be uniform (also to obtain a uniform operation pattern for the treatment plant) intake valves are hand operated according to local flow measurement and or radio instructions from the treatment plant.

The transition tunnel will be excavated from four fronts: the upstream and downstream tunnel portals and from two fronts starting from a vertical shaft arranged at half the tunnel length. Horizontal adits would have been too costly because of their length at the given morphological conditions along the tunnel centerline.

Using 1977 unit prices the implementation cost for the dam and the tunnel would amount to 600 M pesos.

8. The Resettlement Problem

Whilst about 800 persons, living presently in the future inundated reservoir area, need to be resettled elsewhere if the dam is constructed, a larger scale resettlement scheme was anticipated, the main reasons being the presently prevailing land use system of shifting cultivation. The slash and burn principle or *kaingin* system has resulted in the removal of almost the entire natural vegetation in the catchment area with subsequent severe and increasing soil erosion. This fact together with the physical characteristics of the catchment area would produce soil erosion rates of more than 6000 m^3/km^2/year and would have an impact on the economic lifetime of the reservoir.

The small patches of prime and secondary forests identified in 1977 have been further reduced by this practice, so that at present 85-90% of the catchment area are subject to a varying degree of severe sheet and gully erosion with subsequent soil loss. As this practice has been and is still ongoing, the degradation of the catchment area, accelerated by severe overgrazing is progressing. The time when the land productivity is entirely lost due to the severe losses of the fertile top soil layer may be within 25 years.

The reduced vegetation cover, naturally, results in quicker and higher peak runoffs, as infiltration and retention are diminished. The water quality is further deteriorating and higher treatment cost will result. Finally, the lifetime of the reservoir will be reduced due to large sedimentation rates, unless a higher dam will be constructed to compensate for the losses of storage.

To stop and reverse this negative development a comprehensive conservation plan was worked out, comprising a staged reforestation program covering the larger part of the catchment area, combined with controlled high-intensity agricultural development on bench terraces including the resettlement of the entire population of the catchment area to the ridges of the watershed. The main reason for the resettlement of the entire population is to achieve a basic change in present land use practices by better land use management, total banning of shifting cultivation, and introduction of conservation alternatives which would enhance and maintain the vegetative cover, minimize soil erosion and attain good water quality.

In fact, no improvement from any conservation plan can be expected unless present land use practices are radically changed. On the other hand no conservation and resettlement plan will be successful if it is not simultaneously combined with improved livelihood of the resettled population by providing permanent employment in addition to the traditional subsistence income.

It is believed that the resettlement with its changes in life style and living conditions of the population concerned will be accepted since all efforts have been made to inform and familiarize people with the plan; and convincing them that future living conditions including income will be superior to the present ones. The attitude shown by the population was predominantly positive.

The aforementioned points were thus the main concern of the authors of the conservation plan and all efforts were made for a concerted action, in which the Clinet, the Water District, a newly founded Governmental Inter-Agency Committee and the Consultants joined in common efforts in planning with simultaneous information of the population concerned, by making them familiar with the targets of the plan, to discuss with them in particular the legal and compensation questions related to the resettlement, future guaranteed employment, subsistence and income questions, organizational set-up, and considering their proposals as represented by Barrio Captains and school teachers, with respect to setup of village centers, house style, communication, transportation, community life, etc. This involved an extended socio-economic census and a large information campaign, frequent field meetings on a barrio level, and regular meetings of all parties concerned to pave ways for smooth and optimum future implementation of this plan.

9. Reforestation

Detailed investigations showed that the labor force of the population of the catchment area would be completely absorbed by the large scale tree farming project, intensified agricultural activities and all other related construction works and last but not least the dam and tunnel construction. While the latter offer only temporary employment opportunities, the stagewise increasing reforestation scheme would continue to take over and absorb this labor too.

Forest farming would consist of controlled planting of the fast growing Leucaena, commonly known as "Giant Ipil-Ipil," with interplantation of other species with subsequent harvesting of forest products, like leaf meal, firewood, charcoal, and small construction wood. The proposed forest land management system would produce an average cash income of 2500-3000 pesos per year per laborer or between 5000-6000 pesos per family, which is far superior than the present average family income in this and neighboring catchment areas.

A permanent road and trail system will be provided for the transportation of forest products, the system linked to the village centers as well to major access roads.

As troublesome as resettlement for the individual might be, the present plan has tried to minimize negative sociological by-effects. Indeed, the plan has the outstanding advantage that the population need not to be relocated outside of the catchment area but remain in their physical environment and social interactions can be maintained. Resettlement would be on a barrio by barrio basis. The changes from earlier scattered living into more concentrated village centers are not expected to pose problems since the rural character of the new settlements will be maintained by providing each house with a home lot of 700 m^2. Guaranteed employment in the reforestation scheme and subsistence income from agricultural production on terraced land will mean a considerable improvement in living style and income for the majority of these inhabitants.

Studies have shown that by applying strict management and commercial view points in the marketing and sales of the forest products, the project is not only economically but also financially viable.

10. Conclusion

The foregoing has shown that on top of plain engineering for the construction of a high dam, important other aspects have to be dealt with, which deserve equal treatment and planning efforts to avoid social unrest, resistance and delays of the overall project.

The efforts made in this project by thoroughly and early dealing with reforestation, agricultural and last not least the related socio-economic aspects of the resettlement scheme have shown favorable results.

The project would, however, be incomplete if it had not been considered in the light of the current energy crisis.

The completed Lusaran reservoir, will be able to provide continuously a quantity of about 1.8 m^3/s during its economic life time of 50 years or even longer. Together with some drainage water from the transition tunnel the project will be able to provide more than 2 m^3/s by gravity supply, thus allowing to replace almost the entire groundwater supply which is desirable for reasons of pumping energy savings and substantial recovery of the groundwater aquifier.

In fact, Cebu power prices have risen considerably and are with 1.01 P/kWh, the highest in the country and almost 35% higher than generously assumed (including escalation of 10%) only 4 years ago.

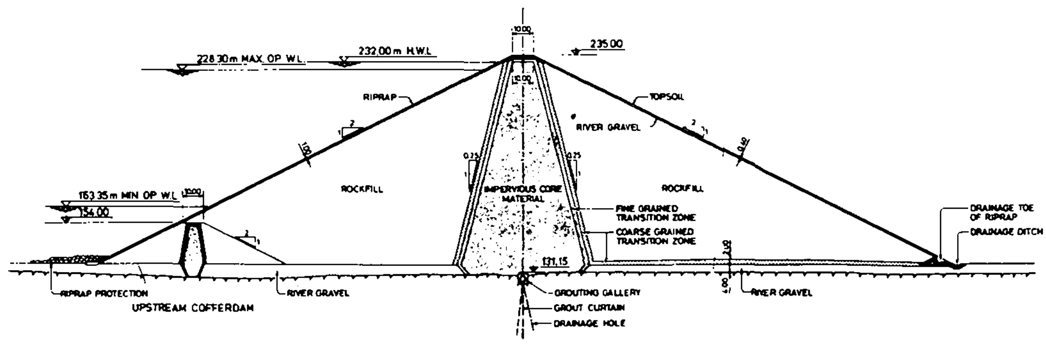
The current energy crisis has also lead to investigations to use the hydro potential of the stored water. While the energy due to the small water quantity is not large (15 GWh/year) it would be sufficient to operate all groundwater pumps of the Water District presently in operation or otherwise contribute to the electrification of the new resettlement within the government's rural electrification program.

The currently faster rising than forecasted water demand to be satisfied combined with already high and still rising energy expenditures related to the groundwater supply system will confront the Metro Cebu Water District in the foreseeable future with even greater financial burden as power bills of the Water District absorb already nearly 60% of the monthly expenditures.

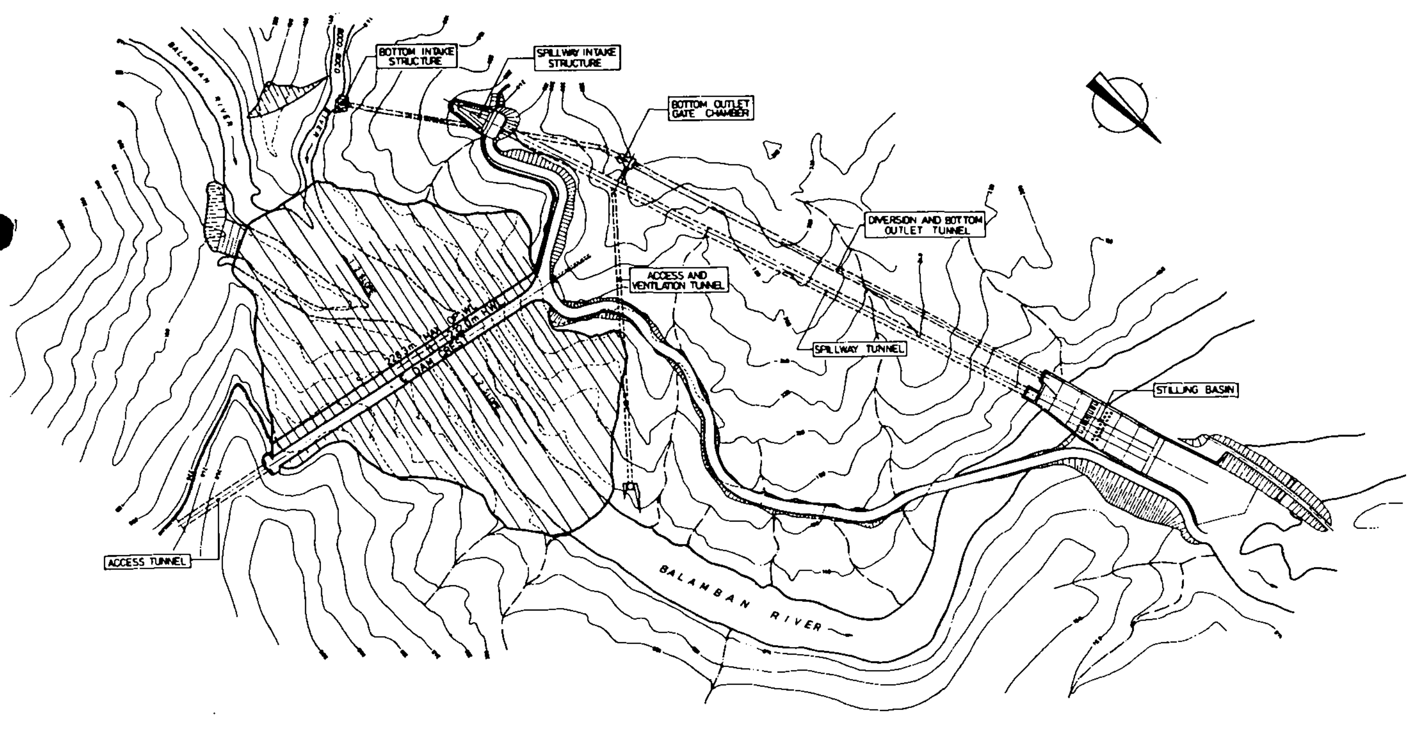
Due to the high energy cost payable in Cebu, the break-even point where surface water will be more economic will thus be much earlier than anticipated in recent studies.

The development of the Lusaran Dam as alternative water resource with its more plentiful long term gravity supply has become therefore more urgent, one point being cost and energy savings.

Considering the financial and economic viability of the reforestation and resettlement component which next to erosion control, elimination of slash and burn landuse will result in a considerable environmental improvement combined with rise of living standard of the resettled population due to employment in this scheme, the, though small, but equally profitable hydropower component, the project's advantages cannot be clearer demonstrated.



TYPICAL CROSS SECTION



LUSARAN DAM

GROUNDWATER DEVELOPMENT FOR METRO CEBU WATER DISTRICT

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Objectives of the Study

The investigations of aquifer in the Metropolitan Cebu Water District will achieve two main objectives:

a) an initial development of groundwater by wells in Pardo-Mananga, Talamban, Consolacion and Compostela areas to cover water demand of the Interim Improvement Period (up to year 1982), and

b) a more exact assessment of the potential for groundwater development to cover water demand beyond the Interim Improvement Period.

Groundwater Investigations

To achieve the mentioned objectives, the following investigations were carried out from 1976 to 1979 in the study area.

1. Collection, compilation and analysis of all available geological and hydrogeological reports pertaining to Cebu area.
2. Location of existing wells, collection and analysis of well records and establishment of the Groundwater Data Bank.
3. Detailed geoelectric investigations of the Maghaway Valley (Mananga River basin), Cabadiangan Valley (Kotkot River basin) and Mactan Island (covered by coral limestone).
4. Planning and supervision of drilling of 16 exploratory/production and 26 production wells.
5. Performance of the 78 controlled pumping test (stepdrawdown and constant discharge/recovery tests) on existing selected wells and new production and exploratory wells.
6. Regular measurements of water level from 1976 to 1979 on 64 wells evenly distributed over the study area.

All data are indexed and assembled into a data bank which provided basis for interpretation of the groundwater conditions and preparation of plans for the future development of groundwater in the Metropolitan Cebu Area.

DESCRIPTION OF THE STUDY AREA

The Metropolitan Cebu is situated in Cebu province which is an elongated island centrally located in the Visayan Region (NEDA's Region VII), latitude 10°20' N longitude 124°00' E. The Cebu Island is 220 km long and almost 40 km wide at its central bulge (see location Map, fig. 1).

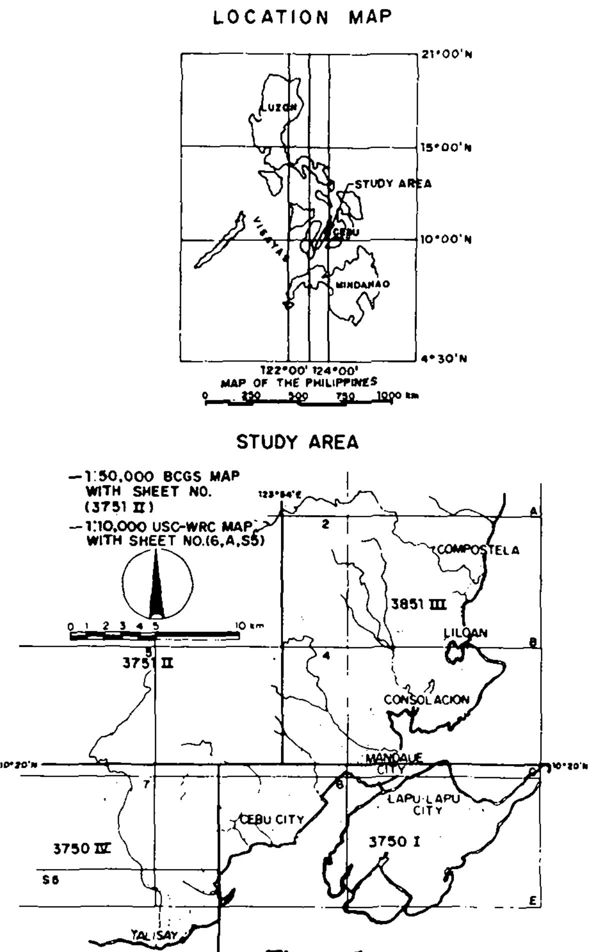

Figure 1

Location Map and Study Area (Metropolitan Cebu Water District, Philippines)

The study area (fig. 1) is situated in the eastern part of the island, within the Metropolitan Cebu boundaries. It occupies a coastal belt extending approx. 30 km from the Mananga River in the south to the Canamucan River in the north. The area's width from the sea to the mountains varies from 48 km and its surface area total 180 sq. km. Elevation rises from zero near the coast to 50 m AMSL at the foot of the limestone hills. The rugged, deeply dissected limestone hills reach elevations over 100 m AMSL.

The main watershed from which surface runoff gravitates towards the Metropolitan Cebu, coincides with the upper boundary of the Mananga and Kotkot River basins. The main watershed extends 15 km inland and covers an area of approx. 450 sq. km. (see also fig. 8).

Climatically, the study area is characterized by a relatively dry season from November to April and a wet season for the rest of the year with the highest rainfall occuring usually between July and October. The average precipitation in the study area is 1,600 mm per year.

Most of the rivers in the study area are nonperennial with high runoff during the rainy season. The perennial rivers are Mananga, Kotkot, Pitogo and Butuanon rivers. The drainage basins (No. 1, 2, 4 and 5 shown in fig. 8) of these rivers extend further inland where precipitation is higher and more evenly distributed over the year than in the coastal area.

The vegetation cover in the coastal area is very scarce leaving the soil vulnerable to severe erosion. This is especially evident in the precipitous coastal hills which consist of corraline limestone and volcanic rocks.

The present population inhabiting MCWD service area is estimated at approx. 0.5 million inhabitants. Highest population densities occur in Cebu, Mandaue and Lapu-Lapu cities. By year 2000 the population of Metro Cebu is projected at about 2 million inhabitants.

GROUNDWATER CONDITIONS IN THE COASTAL AQUIFER OF METRO CEBU

Well Survey

The survey of wells fig. 2 revealed that there are 8724 wells located in the project area (as of 1st October, 1979). Most of the wells (more than 80%) are shallow (20 to 30 m depth), small diameter wells. As shown on fig. 3a the density of wells is highest in densely populated areas of Cebu City, Mandaue City, Tabunok and Poblacion, in the Municipality of Talisay. Fig. 3b shows that the greatest withdrawal of groundwater (more than 2000 cu.m. per sq.km.) occurs in Cebu City and Mandaue City areas. As shown by the position of 250 mg Cl/l isoline in these areas, this withdrawal (over pumping) caused a progressive intrusion of saline water into the wells near the coast. The analysis of withdrawal from wells, divided into different categories of consumers, indicated that approx. 60,000 cu.m. per day of groundwater is presently withdrawn from the aquifer in the study area. As illustrated in fig. 4 the domestic withdrawal represents approx. 50%, while industrial/institutional and public water supply (by MCWD) represents approx. 30% and 20%, respectively.

Aquifers in the Study Area

The coastal belt, in which the aquifer is situated, is approx. 30 km long with width varying from 4-8 km. Landward, the aquifer is in contact with the volcanic rocks of the lower permeability. As seen from fig. 5 and 6, showing simplified cross sections of the aquifer, the poorly consolidated Carcar (corraline) limestone and unconsolidated (alluvial and recent) deposits of sand and gravel compose the aquifer in the study area. Further from the coast the aquifer consists of carcar limestone whose thickness increases seaward and exceeds 500 m near the coast.

In the coastal areas, around rivers and in the valleys, carcar limestone is overlain by unconsolidated sediments consisting of alternating layers of clay silt, sand and gravel and their mixtures. The thickness of these layers increases seaward and attains approx. 50-70 m near the coast.

The main part of the aquifer is of the water table type. Locally, inland and near the coast semi-confined aquifers are encountered.

Other aquifers in the study area are situated inland, in the river valleys (unconsolidated deposits) and on Mactan Island (coral limestone).

Water Level Conditions and Groundwater Flow

Historical Records of Water Level

The historical records of water level in the study area originate mainly from the drillers log, and were collected during the well survey. There are 538 boreholes in the area with records of water level. The oldest records are from the late fifties. As these records give water level at the time of drilling, the year of water level measurement varies from well to well.

As seen from fig. 7, illustrating the change in water level due to groundwater abstraction during the last 20 years, the withdrawal of groundwater since 1960 caused the lowering of water level at the rate of approx. 0.5 m per year in the majority of wells. In the coastal part of Cebu and Mandaue areas, where both density of wells and withdrawal are highest, the water level has been lowered up to 6 m below sea level, causing the intrusion of saline water into the wells in these areas. (See also fig.

3a+b, 5 and 8). In the coastal areas without significant withdrawal, the water level is still above sea level. (See fig. 6).

The analysis of the historical records of water level from wells in different areas indicate that until the early sixties, free flowing wells could be found at many places in downtown Cebu and Mandaue City. However, as the withdrawal of groundwater intensified the free flow from these wells ceased.

In the Talisay area, near the coast e.g. in Poblacion and Tanque (southern part of the study area), there are still free flowing wells, with water level rising up to about 0.5 m above ground. (See also fig. 8). However, as the withdrawal of groundwater in Talisay area intensified the cessation of the free flow from wells could be expected in the future.

Water Level Conditions in 1979

As mentioned above, the year of water level measurement varies for existing wells. Therefore, these records do not reflect accurately the present water level conditions in the area.

To obtain a more accurate picture, the water level was measured in the period from March to April 1979 in 64 wells, evenly distributed over the study area. The contours of the groundwater surface and the direction of groundwater flow, as shown on fig. 8, are primarily based on these measurements.

Following other data are also presented on this Map: average discharge of MCWD wells, present withdrawal as per consumer category shown by vertical columns, graphs showing fluctuations in static water level (since 1976) from 9 wells and rainfall data from 4 rain gaging stations and the position of the saltwater edge i.e., 50 mg C1/1 isoline (data from analysis performed in 1976).

Hydraulic Gradient and Configuration of Water Level Contours

The records indicate that the elevation of water level in the study area is from zero near the coast to over 20 m AMSL in wells within limestone hills.

As it could be seen from the distance between the contour lines in fig. 8, the hydraulic gradient varies from 0.2% to 1% depending on the volume of groundwater flow in the aquifer and the withdrawal in different parts of the area.

In the areas with undisturbed groundwater flow, the hydraulic gradient is from 0.2% to 0.5% while in the areas in which the withdrawal of groundwater takes place, a hydraulic gradient up to 1% could be encountered (e.g. Cebu City area).

As shown in fig. 8, the equipotential lines in Cebu City and Mandaue City are drawn inland, and the deep cones of depression, with closed contours of water level are created near the coast due to intensive withdrawal of groundwater. In these depressions, the water level is lowered several metres below sea level. Consequently, a progressive salinization of the aquifer in the coastal areas occured (see also fig. 7). An area of diversion (within which the flow of groundwater is towards the centres of withdrawal) of approx. 22 sq. km. (length 5.5 km, width 4 km) is created in the mentioned areas.

The analysis of C1 content from groundwater samples taken from shallow wells in 1976, indicated that the position of saltwater edge is approx. 0.5 km from the coast in Cebu City and Mandaue City downtown areas. (See also fig. 3a).

As it could be seen from fig. 8 in the areas outside Cebu City and Mandaue City, the groundwater flow is still undisturbed (i.e. perpendicular to the coast), due to a relatively small withdrawal from the aquifer. The contour lines are generally parallel to the coast with the zero equipotential line still situated at some distance off shore. The areas with undisturbed groundwater flow extend from the Buhisan River southward to the Mananga River in the Municipality of Talisay and Northward from Talamban over Consolacion, Liloan to Canamucan River in the Municipality of Compostela. In these areas the potential for groundwater withdrawl is practically intact.

Relationship between the Monthly Rainfall and the Fluctuations in Water Level

As shown on the water level graphs in fig. 8, the average observed yearly amplitude of water level fluctuation is from 1.5 to 2 m. (Higher amplitude is observed too during excessively wet year, e.g. in 1980). The highest water level is usually observed in November-December while the lowest water level is observed in June-July. The water level rises for 4 months from June to December, during the rainy season, and declines during the 8 months from December to June. Hence, the seasonal fluctuations in water level coincide with the periods of dry and wet seasons.

By comparing the monthly rainfall data with water level fluctuations, it appears that when rainfall is lower than approx. 100 mm per month, the water level continues to decline. In the period from June to November, during which the monthly rainfall exceeds 100 mm, the increase in water levels is observed, indicating recharge into the aquifer from precipitation. Hence, the critical period for calculation of the long term consequences of withdrawal is 8 months without recharge during which the available drawdown in a well or the well field should not be exceeded.

Specific Capacity and Transmissivity

Aquifer/well yield varies from place to place, but it is generally regarded as moderate to good.

Fig. 9 shows distribution of the specific capacities for the representative sample of wells in the study area. As seen in fig. 9 the specific capacity varies from less than 5 cu.m./hr per m of drawdown to more than 100 cu.m./hr per m of drawdown with the majority of wells (71%) having the specific capacities of less than 20 cu.m./hr per m of drawdown. Locally, there are places in both aquifers with wells exhibiting exceptionally high specific capacities (yields).

High yield of some wells in carcar limestone is attributed to the increase in secondary permeability due to fracturing and solution channels (e.g. in Talamban well field, Mactan Island and localities in the northern part of the study area). During pumping test on these wells the double-porosity effect is observed on the time-drawdown data, which is characterized by an instantaneous, comparatively small drawdown, followed by a quasi-steady-state flow lasting at least one day. After a quasi-steady-state flow ceases to influence drawdown data, the water level starts to decline again indicating that a whole aquifer (fissures and matrix) contributes to groundwater flow towards a well. Generally, due to absence of the storage effect in the early time-drawdown data, it is concluded that the groundwater flow towards such a well is governed by a high permeability zone rather than a single fissure or channel.

Whenever the pumping equipment allowed for a pumping test of longer duration, T-value is determined from the late part of time-drawdown data pilot. Fig. 10 shows a typical time-drawdown semilog plot from a well affected by a double porosity effect. Both semilog and double-log plots of the time-drawdown data were used in the analysis for determination of T-values from wells in which the double-porosity effect is observed.

In the unconsolidated sediments, around rivers, the high specific capacities (and well yield) are associated with sand and gravel deposits e.g. near Mananga and Kotkot Rivers. The analysis of pumping test data indicate that the aquifers in the river valleys (for instance in the Maghaway Valley, Mananga River Basin and Kotkot Valley, Kotkot River Basin) offer a good potential for groundwater withdrawal, through induced infiltration from the river.

The limestone aquifer at Mactan, despite its high yielding properties, cannot support a large withdrawal due to a comparatively thin lense of fresh water (thickness of about 25 m in the centre of the island) which limits the drawdown and consequently the well yield to no more than 25 cu.m./hr hr per well.

The analysis of pumping test data indicated that the transmissivity coefficient of aquifer in the study area varies from 10^{-4} to 10^{-1} sq.m./sec.

To illustrate the relationship between the specific capacity and the transmissivity for wells drilled before 1977 and wells drilled during this investigation, the plot fig. 11 and 12 is prepared.

As seen in these figures the results of the linear regression analysis indicate that, although the plotted Q/s_w-values contain the losses other than the formation loss, a significant relationship between Q/s_w and T-values for both groups of wells is obtained with the correlation coefficients ranging from 0.86 to 0.91 for the old and new wells, respectively.

From the results of the step drawdown test it was determined that the greater scatter of the points for older wells (fig. 11) is mainly due to greater drawdown (head losses) inside and/or in the immediate vicinity of a well bore. This could be attributed to an erroneous placement of the screen intervals as well as to an inadequate open area of the screen, where such a screen is applied. TV-inspection has shown that the screens in the old wells are generally made of the slotted pipes with an irregular spacing of slots and a small open area. Furthermore, TV survey has shown that a great many slots are covered by the carbonate deposits. This causes a greater entrance velocity of the water into a well and consequently produces a greater drawdown (well loss) which decreases the specific capacity of such wells. From the comparison of the specific capacities between the old and new wells it could be concluded that the pumping from old wells is uneconomical.

Chemical Character of Groundwater

As it can be seen from the trilinear diagram fig. 13, the dominant ions in groundwater from the study area, are those of alkaline earth and weak acids, namely Ca, Mg and $HC0_3$.

Such groundwater is characteristic for calcareous formation i.e. its hardness is high (more than 120 mg $CaCo_3/1$). The water is suitable for domestic purpose but should be softened when used in boilers.

The silica content of approx. 32 mg $Si0_2/1$ which is also found in the groundwater, could cause scale when used in boilers. The presence of silica could indicate that some groundwater comes from the volcanic rocks which are in a contact with carcar limestone further inland.

Locally, a higher $N0_3$-content (higher than 40 mg $N0_3/1$) is observed indicating a contamination of infiltrating rain by excreta. In densely populated areas the excreta are presumably of human origin. In wells from the Talamban well field the higher $n0_3$-content is observed for short periods in connection with rain. Here, a periodical occurence of higher $N0_3$-content is due to contamination of infiltrating rain while passing through excreta deposited by bats, which reside in the caves occuring in carcar limestone further inland. The wells exhibiting higher nO_3-content should be monitored and when NO_3-content exceeds the permissible limits, such groundwater should be diluted before its distribution takes place.

The taste and odor of groundwater from wells in the study area is generally regarded as satisfactory. Normally, the clorination of rawwater would be sufficient before distribution.

Aquifer recharge

From the analysis of rainfall data, fluctuations in water levels, the groundwater flow through aquifer and the chemical character of groundwater, it is concluded that the aquifer is recharged partially through infiltration (up to 60%) from precipitation over aquifer surface area (coralline limestone and alluvial and recent deposits) and partially through underflow (up to 40%) in the form of seepage at the contact between the limestone and the volcanic rocks.

The renewable groundwater flow in the coastal aquifer is estimated at approx. 55 mill. cu.m./year (equal to 150,000 cu.m. per day). However, about 2/3 of this flow, or approx. 100,000 cu.m. per day only, could be withdrawn without undesirable consequences to water quality (saltwater intrusion).

The potential for withdrawal from the river valleys inland is in the order of magnitude of approx. 40,000 cu.m. per day.

The available (sustained) yield of aquifer at Mactan is estimated at approx. 2.7 mill. cu.m./year (equal to approx. 7,500 cu.m. per day) of which approx. 60% is already utilized.

The total potential for groundwater withdrawal (sustained yield) from Cebu coastal aquifer and other aquifers in the study area (river valleys and Mactan Island) is estimated at approx. 140,000 cu.m. per day.

ASSESSMENT OF AQUIFER/WELL YIELD

Determination of average Well Loss

In order to find the relationship between the hydraulic properties of wells and aquifer which could be used for prognosis of the yield from future wells, the values of well loss constant (C) are plotted versus transmissivity (T) on a double-log paper as shown in fig. 14 and analysed by a linear regression method.

Although the smaller scatter of points in this graph could be desired, the correlation tendency is evident (the correlation coefficient = 0.86) and the plot from majority of well points established a significant relationship between T and C-values which is expressed in the empirical equation, $C = 9.3\ T^{-1.283}$. This equation if adopted for further calculations of the expected well loss from an average well in the study area.

Expected Discharge from Wells

The results of above mentioned analysis are used to construct the graph, fig. 15 from which the expected average well discharge, for a given aquifer transmissivity, available drawdown and period of pumping could be determined.

The graph fig. 15 is constructed by using the following equation:

$$s_w = (1.98T^{-1.03} + 9.3\ T^{-1.283}\ Q)\ Q\ (m)$$

The assumptions, within which the application of the above formula is valid, are given in fig. 15. Determination of expected discharge is illustrated in the following examples.

From the Map fig. 8, the available drawdown in the vicinity of Mananga River near Tanunok (southern part of the study area) is approx. 7 m. The average T-value of aquifer in this area is 0.03 sq.m./s. By finding the intersection point in fig. 15 between s_w = 7 m and T-value 0.03 sq.m./s it could be seen that a single well yields approx. 230 cu.m./hr (Q/s_w = 27.5 cu.m./hr per m of drawdown). During the actual test the well no. W1. 1 in this area, yielded 252 cu.m./hr with 8.3 m of drawdown or Q/s_w = 30.4 cu.m./hr (after 2 days of testing). Similar results have been obtained from other wells in this area. From the second part of the above equation, the well loss is found as follows:

$$CQ^2 = 9.3\ T^{-1.283}\ Q^2 = 3.41\ m$$

or approx. 41% of the total drawdown in the well.

Should there be other wells in the vicinity, like four production wells in the Mananga well field, the interference drawdown must be subtracted from the available drawdown in a single well. Consequently, the optimum discharge would decrease to about 180 cu.m./hr, which is a recommended discharge for each of the 4 new wells constructed in the Mananga well field.

Apart from the variation in T-values, the main factor influencing the magnitude of expected discharge in the study area is the available drawdown, which decreases towards the sea.

The influence of the small available drawdown on discharge is best illustrated on the Mactan Island. The pumping test results indicate an aquifer with exceptionally high T-value (order of magnitude 0.05 sq.m./s). However, as the elevation of water level is 0.5 m at the center of the island and 0.2 m near the coast, the available drawdown is from 10 cm to 20 cm near the coast and centre of the inland, respectively. From the graph fig. 15 it is found that the discharge from a well cannot exceed 15 cu.m./hr and 25 cu.m./hr for the respective available drawdown of 0.1 m and 0.2 m and T-values in between 0.05 sq.m./s and 0.1 sq.m./s, respectively.

Discharge Map

By using graph fig. 15, the elevation of water level from fig. 8 and T-values from the controlled pumping tests, the discharge Map fig. 16, showing the expected average discharge from a well drilled in the study area is constructed. The maximum available drawdown in the coastal aquifer is defined as the distance between the actual elevation of water level and the sea level.

After the calculation of the optimum discharge of each well point, the study area is subdivided into 4 zones with respect to the expected optimum discharges.

It should be mentioned here that deviations may occur between the expected and the actual discharge due to inhomogeneities in the aquifer and variations in hydraulic properties at the future well site.

Zone 1, Discharge less than 20 cu.m./hr

In the first zone, near the coast, with an available drawdown up to 1 m, the optimum discharges of less than 20 cu.m./hr per well could be expected. Large volume of groundwater could be withdrawn only from a comparatively great number of wells spread evenly along the coast. In an undisturbed aquifer such manner of withdrawal is advantageous, as it would benefit from the natural groundwater flow up gradient. The actual situation indicates however, that in the Cebu City and Mandaue City areas the potential for additional withdrawal is exhausted by pumping from the existing wells which lowered water level below sea level. Most of the wells in this area penetrate into an aquifer consisting of unconsolidated sand and gravel deposits. The expected depth of drilling is approx. 20 m below ground.

Zone 2, Discharge from 20-50 cu.m./hr

In the second zone, which covers an area further inland, with an available drawdown up to 3 m, the optimum discharges from 20-50 cu.m./hr per well could be expected.

The actual discharge of the majority of wells in this zone are within the mentioned discharge intervals. In this zone, the aquifer consists of both unconsolidated sediments and carcar limestone. The depth of drilling in this zone is approx. 35 m below ground. As it can be seen from the Map fig. 16, the zones 1 and 2 cover the largest part of the study area.

Zone 3, Discharge from 50-100 cu.m./hr

In the third zone, with an available drawdown up to 5 m, the expected discharge is from 50-100 cu.m./hr per well. This zone is situated in an elevated area (15-30 m AMSL) covered by carcar limestone. Wells from the new Consolacion well field (northern part of the study area), which are within this zone, have above mentioned range of discharge. The depth of drilling in this zone is approx. 50 m below ground.

Zone 4, Discharge over 100 cu.m./hr

In the fourth zone, with an available drawdown of more than 8 m, the optimum discharge over 100 cu.m./hr per well could be expected. The lateral extent of this area is generally small and the actual well sites are found at the foot of the carcar limestone hills (ground elevation of approx. 40 m AMSL).

The aquifer consists of carcar limestone with exception of the unconsolidated sediments in the Mananga riverbed near Talisay.

When placing future wells in carcar limestone, a study of the lineaments and tectonic structures should be made and a well should be placed in the areas in which such features are prominent. The depth of drilling in this zone is approx. 70-80 m below ground.

It should be mentioned here that the wells with discharges in excess of 200 cu.m./hr have been drilled in this zone, e.g. Talamban new well field and surrounding wells as well as the exploratory wells in the northern part of the study area.

In the carcar limestone such wells are associated with aquifer having high secondary permeability due to fracturing and solution channels.

In unconsolidated sediments, the wells with discharge greater than 100 cu.m./hr, e.g. in Mananga well field, are found in the areas with sand and gravel deposits having high permeability or high ability to transmit water.

Expected Discharge in the Hilly Areas

Beyond the zone 4, further inland, the yield of wells decreases significantly, mainly due to lower permeability of the penetrated portion of carcar limestone. Discharge up to 50 cu.m./hr from wells placed in the hilly area of carcar limestone could be expected.

The Cost of Pumping of Groundwater

The main factors influencing the cost of pumping of groundwater are the total dynamic head and the cost of electricity.

The following formula is used for calculation of the energy consumption to lift 1 cu.m. or groundwater to the ground.

$$\text{Energy/m}^3 = 4.87 \times 10^{-3} \times H \times \frac{P}{100}$$

in centavos per KWH/m^3

where:

H = total dynamic head, in m

$\frac{P}{100}$ = cost of electricity, in fraction of Peso

A combined efficiency factor for both motor and pump of 0.56 is used in the above formula.

In the study area, the total dynamic head is defined as the length from the optimum pumping level to the ground surface. As the optimum pumping level for all discharge zones in map fig. 16 is set near sea level the cost of pumping will increase with the elevation of ground. The cost, to lift 1 cu.m. to the surface in the different discharge zones, at a prevailing cost of electricity of P0.75 is given in Table 1. (1979 index).

Zones	H average in m = elevation of ground in m AMSL	Cost centavos/m^3
1	15	5.48
2	25	9.13
3	35	12.78
4	45	16.43

Table 1. The cost to lift 1 m^3 of groundwater to the ground in the different discharge zones in the MCWD area.

As can be seen from Table 1, the cost to lift 1 cu.m. to the ground increases proportionally with the increase in total dynamic head which corresponds to ground elevation.

In addition to the cost of electricity, the construction cost, operation and maintenance and administration cost form the basis for calculation of the total production cost of 1 cu.m. of groundwater in the study area of a given time.

PROGRAMME FOR DEVELOPMENT OF GROUNDWATER IN THE MCWD AREA

The greatest potential for groundwater development is in the areas outside of the present consumption, namely in the northern area. However, as the southern part of the area is closer to the existing distribution system, the recommended phases of development, will concentrate initially on developing all available groundwater from this area.

However, this will involve a tradeoff between the replacement of an inefficient withdrawal from the old, existing wells with a more efficient withdrawal from the new wells. Hence, the actual augmentation of the total volume of groundwater from this area will not be significant.

When the aquifer potential in the southern area is exhausted, the development of groundwater from the northern area is scheduled.

In fig. 17 the projected MCWD water demand and the recommended phases of groundwater development are illustrated.

Interim Improvement Programme, period 1976-1982

Two drilling programmes were carried out during this investigation.

In the first drilling programme, from 1977 to 1978, 10 production wells and 7 exploratory wells were drilled. From these wells, 10 are finally scheduled for production in the Interim Improvement Period.

In the second drilling programme, from 1978 to 1979, 16 production wells and 9 exploratory wells were drilled. From these wells, 11 are finally scheduled for production in the Interim Improvement Period.

The new production wells are placed further from the coast to minimize the risks of the intrusion of the sea water. In fig. 18 and 19 a+b location and typical design of exploratory and production wells are illustrated. Summary of data from exploratory and production wells is presented in Table 2.

SUMMARY OF ORIGINAL WELL DRILLING PROGRAM
PERIOD OF CONSTRUCTION 1977 - 78

SITE	CONTRACT WELL NO.	WELL NO.	CASING DIAM. (inch)	CONTRACTOR	DRILLING METHOD	AQUIFER FORMATION	DISCHARGE/ DRAWDOWN (m^3 per h/m)	SPECIFIC CAPACITY (m^3 per h/m)	AVAILABLE YIELD (m^3/h)
PRODUCTION WELLS									
MANANGA	W 1.1	7294	12D	WOOLBRIGHT	PERCUSSION	SAND/GRAVEL	[illegible]/10.0 •	20.0	100x
MANANGA	W 1.2	7307	14D	WOOLBRIGHT	PERCUSSION	SAND/GRAVEL	300/ 8.2•	34.5	100x
MANANGA	W 1.3	7295	12D	WOOLBRIGHT	PERCUSSION	SAND/GRAVEL	300/10.8*	27.8	100x
MANANGA	W 1.4	7308	14D	WOOLBRIGHT	PERCUSSION	SAND/GRAVEL	240/ 8.9•	27.9	100x
MANANGA	W 1.5	7296	12D	WOOLBRIGHT	PERCUSSION	SAND/GRAVEL	66/ 3.9•	16.9	50x
LAGTANG	W 2.2	7297	12D	WRSOC	ROTARY	LIMESTONE	17/27 •	0.63	10
LAGTANG	W 2.3	7309	12D	WRSOC	ROTARY	LIMESTONE	17.5/15.6•	1.12	15
COMPOSTELA	W 3.1	7298	10D	GOLDWATER	PERCUSSION	LIMESTONE	14.4/11.9•	1.21	10
COMPOSTELA	W 3.2	7299	10D	GOLDWATER	PERCUSSION	LIMESTONE	29/ 5.7•	5.1	25x
COMPOSTELA	W 3.3	7310	10D	GOLDWATER	PERCUSSION	LIMESTONE	42/13.2•	3.2	25x
EXPLORATORY WELLS									
MAGHAWAY	K 1.1	7300	8D	WRSOC	ROTARY	SAND/GRAVEL	67/ 0.85•	79.0	100
BUNISAN	K 1.2	7301	8D	WRSOC	ROTARY	LIMESTONE	5.9/13 •	0.45	5
BUNISAN	K 1.3	7302	8D	WRSOC	ROTARY	LIMESTONE	5.2/13 •	0.17	5
CONSOLACION	K 2.1	7303	10D	GOLDWATER	PERCUSSION	LIMESTONE	105/13.2•	8.0	100x
TALAMBAN	K 2.2	7304	10D	GOLDWATER	PERCUSSION	LIMESTONE	98/ 2.8•	35.0	100x
MANDAUE	K 2.3	7305	8D	GOLDWATER	PERCUSSION	LIMESTONE	50/10.9•	4.6	50
MACTAN	K 2.4	7306	24D	GOLDWATER	PERCUSSION	LIMESTONE	41/ 0.35•	121.0	25x

SUMMARY OF EXTENSION WELL DRILLING PROGRAM
PERIOD OF CONSTRUCTION 1978- 79

SITE	CONTRACT WELL NO.	WELL NO.	CASING DIAM. (inch)	CONTRACTOR	DRILLING METHOD	AQUIFER FORMATION	DISCHARGE/ DRAWDOWN (m^3 per h/m)	SPECIFIC CAPACITY (m^3 per h/m)	AVAILABLE YIELD (m^3/h)
PRODUCTION WELLS									
TALAMBAN	W 4.1	7311		WOOLBRIGHT	PERCUSSION	LIMESTONE	7.2/ 5.1*	1.4	xx
TALAMBAN	W 4.2	8702	14D	WOOLBRIGHT	PERCUSSION	LIMESTONE	306/ 0.21•	1457.0	100x
TALAMBAN	W 4.3	8700	14D	WOOLBRIGHT	PERCUSSION	LIMESTONE	43.9/ 2.28*	19.3	30x
TALAMBAN	W 4.4	8699		WOOLBRIGHT	PERCUSSION	LIMESTONE	40/ 6.6 *	6.1	xx
TALAMBAN	W 4.5	8701		GOLDWATER	PERCUSSION	LIMESTONE	5.5/ 3.3**	1.7	Obs. well
TALAMBAN	W 4.6	8703		GOLDWATER	PERCUSSION	LIMESTONE	4.9/ 3.7**	1.3	xx
TALAMBAN	W 4.7	8709	14D	GOLDWATER	PERCUSSION	LIMESTONE	305/ 1.05•	290.0	100x
TALAMBAN	W 4.8	8704	14D	WOOLBRIGHT	PERCUSSION	LIMESTONE	302/ 0.40•	755.0	100x
TALAMBAN	W 4.9	8719	12D	WOOLBRIGHT	PERCUSSION	LIMESTONE	70/ 4.20*	16.7	50x
TALAMBAN	W 4.10A	8722		WOOLBRIGHT	PERCUSSION	LIMESTONE	45/ 0.37*	122.0	xx
TALAMBAN	W 4.10B	8724	14D	WOOLBRIGHT	PERCUSSION	LIMESTONE	106/ 0.93•	349.0	100
CONSOLACION	W 5.1	8707	14D	GOLDWATER	PERCUSSION	LIMESTONE	237/ 9.4 •	25.2	145x
CONSOLACION	W 5.2	8678	14D	GOLDWATER	PERCUSSION	LIMESTONE	174/10.6 •	16.4	145x
CONSOLACION	W 5.3	8711	14D	GOLDWATER	PERCUSSION	LIMESTONE	79/11.4 •	6.9	50x
CONSOLACION	W 5.4	8679	14D	GOLDWATER	PERCUSSION	LIMESTONE	65/10.5 •	6.2	50x
CONSOLACION	W 5.5	8708	14D	GOLDWATER	PERCUSSION	LIMESTONE	145/13.9 •	10.4	100x
EXPLORATORY WELLS									
KITOT	K 3.1	8717	10D	WOOLBRIGHT	PERCUSSION	LIMESTONE	45/ 2.9 •	16.0	100
[illegible]	K 3.2	8720	10D	WOOLBRIGHT	PERCUSSION	LIMESTONE	100/ 5.89•	17.0	100
LAWAC	K 3.3	8723	10D	WOOLBRIGHT	PERCUSSION	LIMESTONE	49/ 1.23 •	39.8	100
GILATAMAN	K 4.1	8721	10D	GOLDWATER	PERCUSSION	LIMESTONE	73.8/ 6.2 •	[illegible]	80
BABANA	K 4.2	8677	10D	GOLDWATER	PERCUSSION	LIMESTONE	26/ 7.4 •	3.5	30
TAWASON	K 4.3	8710	10D	GOLDWATER	PERCUSSION	LIMESTONE	30/12.4 •	2.4	30
DANLAG	K 4.4	8713	10D	GOLDWATER	PERCUSSION	LIMESTONE	68.5/14.2 •	4.8	50
BAY-ANG	K 4.5	8714	10D	GOLDWATER	PERCUSSION	LIMESTONE	94/ 1.7 •	55.3	100
SAMBAG	K 4.6	8715	10D	GOLDWATER	PERCUSSION	LIMESTONE	93/ 0.88•	105.7	100

NOTE. Specific capacity determined from
• Final Pumping Test
* Preliminary Pumping Test on open hole
** Bailer Test
x Finally scheduled as production well.
xx Abandoned.

Table 2. Summary of data from exploratory and production drilling programme, MCWD area.

The 21 production wells are able to yield total approx. 46,000 cu.m./day during 20 hours of pumping period. The 11 exploratory wells, which are designed so they can also be used as production wells, are able to yield approx. 17,000 cu.m./day for the same pumping period as above. The cost of drilling of 42 new wells was approx. P7.5 mill. (about 1 mill. US Dollars).

At the end of this period a total of 55 MCWD production wells are supposed to be in operation of which 29 are the old wells. The total withdrawal of groundwater by the MCWD will reach approx. 60,000 cu.m./day which is about three times more than the withdrawal in 1976. Furthermore, all private and domestic wells in the area (about 8,300 wells) will still withdraw approx. 45,000 cu.m./day. Hence, the total withdrawal from the coastal aquifer in 1982 will amount to approx. 105,000 cu.m./day. As most of withdrawal by others than MCWD is concentrated in the same area as before, the private and domestic wells close to the coast will experience an increase in Cl-content and some will have to be abandoned.

Future Development Programme

Beyond the Interim Improvement Period the following phases of groundwater development are scheduled:

	Number of new production wells
Period 1982-1983*	25
Period 1983-1985**	11
Period 1985-1988	21-26

* In this period the 29 MCWD wells are supposed to be replaced by more efficient new wells, which are situated at some distance from the coast to minimize the risk of saltwater intrusion.

**In this period, most of the private and domestic wells near the coast will either be phased out or they will be abandoned, due to increase in the Cl-content.

The envisaged number of new production wells (57-62), to be drilled in the period from 1982-1988, is an estimation only. The final number of production wells in each new well field could be higher or lower depending on the aquifer yielding properties at each well site. The total of 83-88 MCWD production wells is estimated to be in operation in 1988. The production wells are supposed to operate 20 hours per day the year round, at a recommended discharge rate.

Fig. 20 shows the contours of groundwater surface in aquifer in the Metropolitan Cebu Area in year 1988, after all phases of groundwater are implemented. As seen from this figure are coastal and other aquifers in the area will eventually provide 142,000 cu.m./day by which the aquifer potential within the study area will be exhausted. As a consequence of this withdrawal the saltwater edge will be moved inland to a distance of approx. 0.5 km from the coast. Provided that the withdrawal from the coastal aquifer remains at about 100,000 cu.m./day and if the recharge remains approx. the same, the position of the saltwater edge will not be changed significantly in relation to the position indicated in fig. 20.

The optimum development schedule for new well fields would aim at always having sufficient extra capacity in wells to cover the maximum water demand at least one year ahead of the actual need. This would provide for an orderly development and prevent water shortages.

By being able to withdraw 142,000 cu.m./day of groundwater the Metropolitan Cebu Water District could provide piped water to approx. 900,000 inhabitants which is close to the projected population figure in the year 1988. Consequently, the withdrawal by private and domestic wells in the MCWD service area will be brought to minimum, which is the ultimate goal of the initiated water supply development in the Metro Cebu area.

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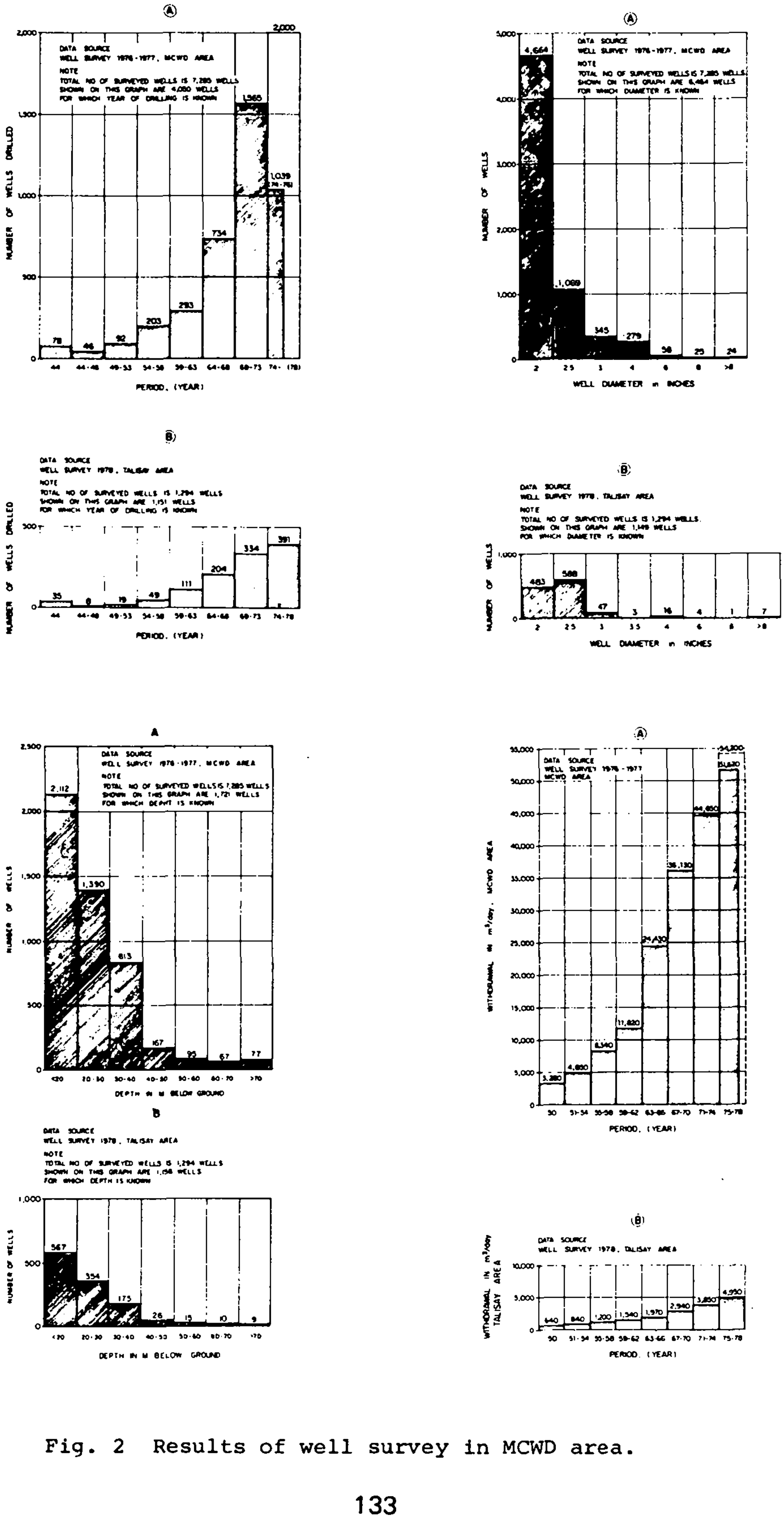


Fig. 2 Results of well survey in MCWD area.

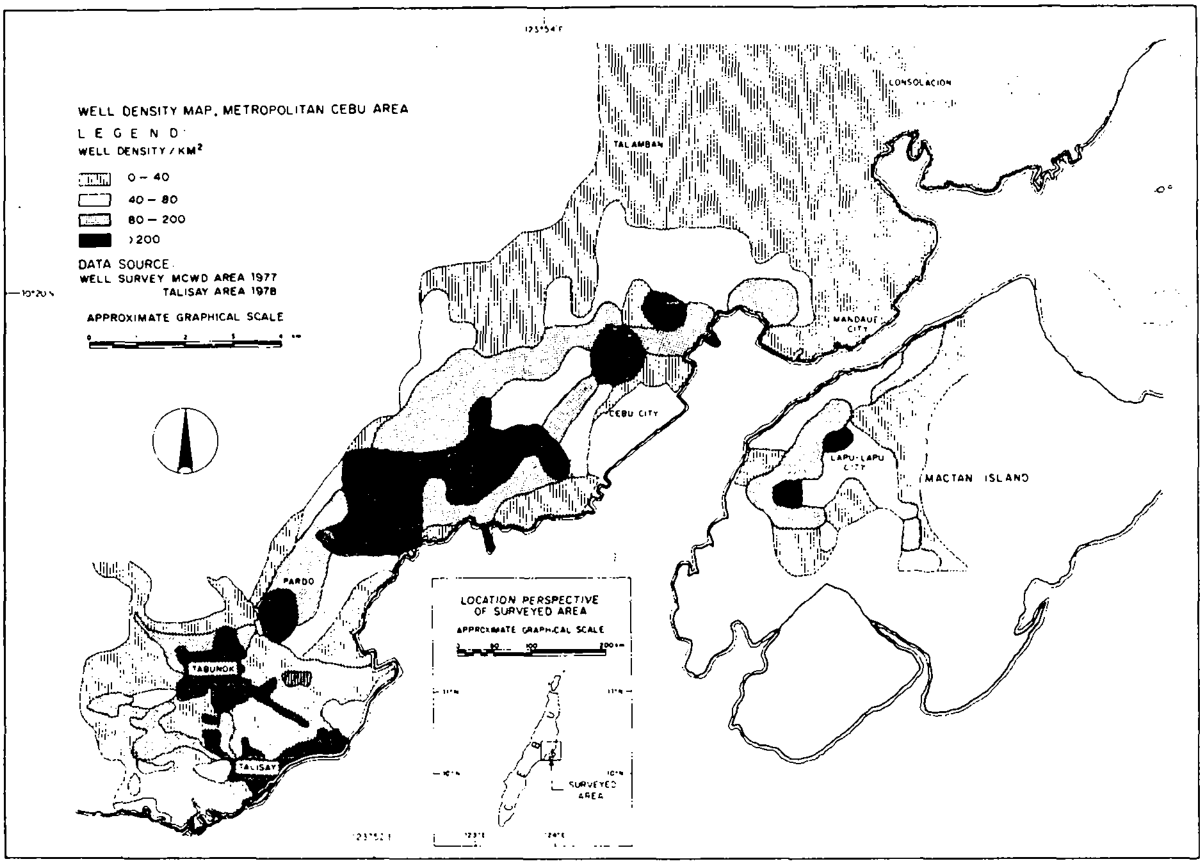


Fig. 3a Map showing well density in MCWD area.

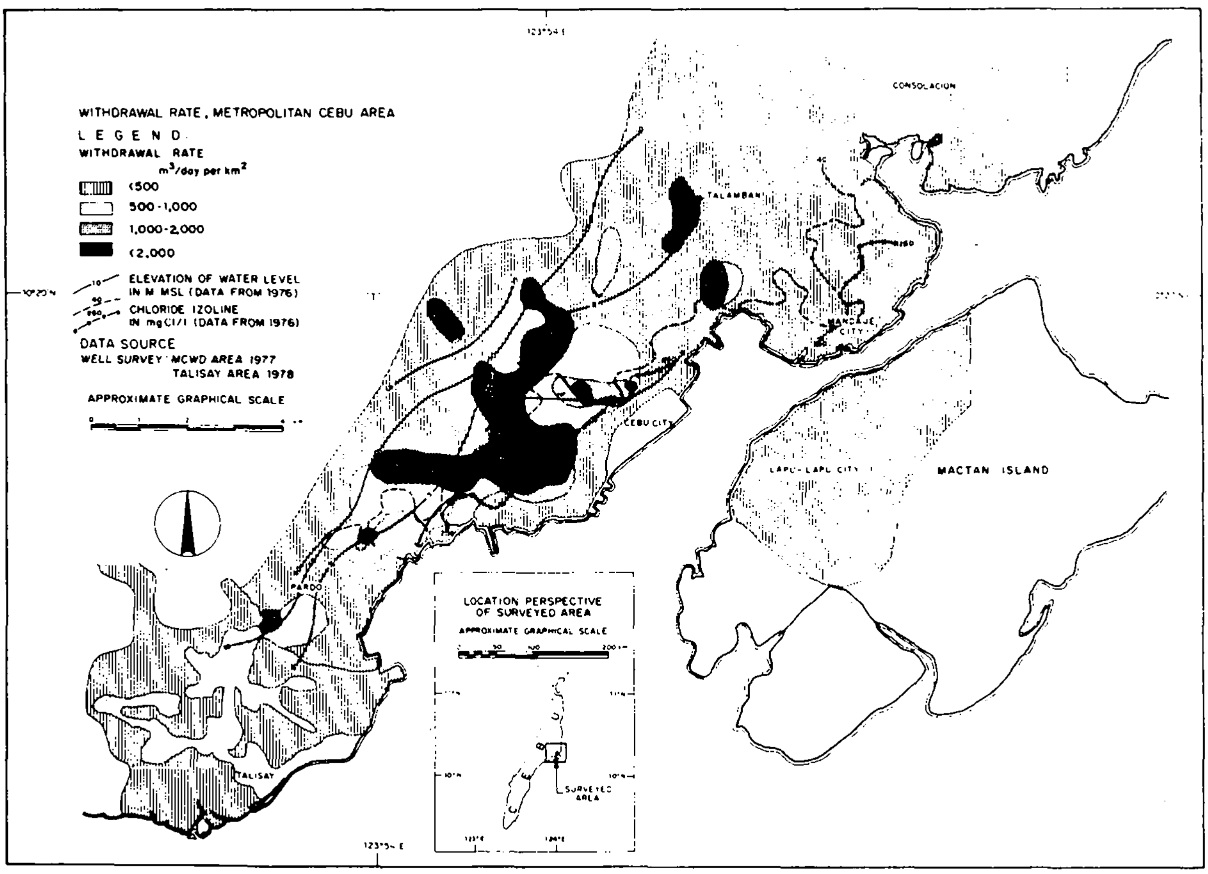


Fig. 3b Map showing withdrawal rate in MCWD area.

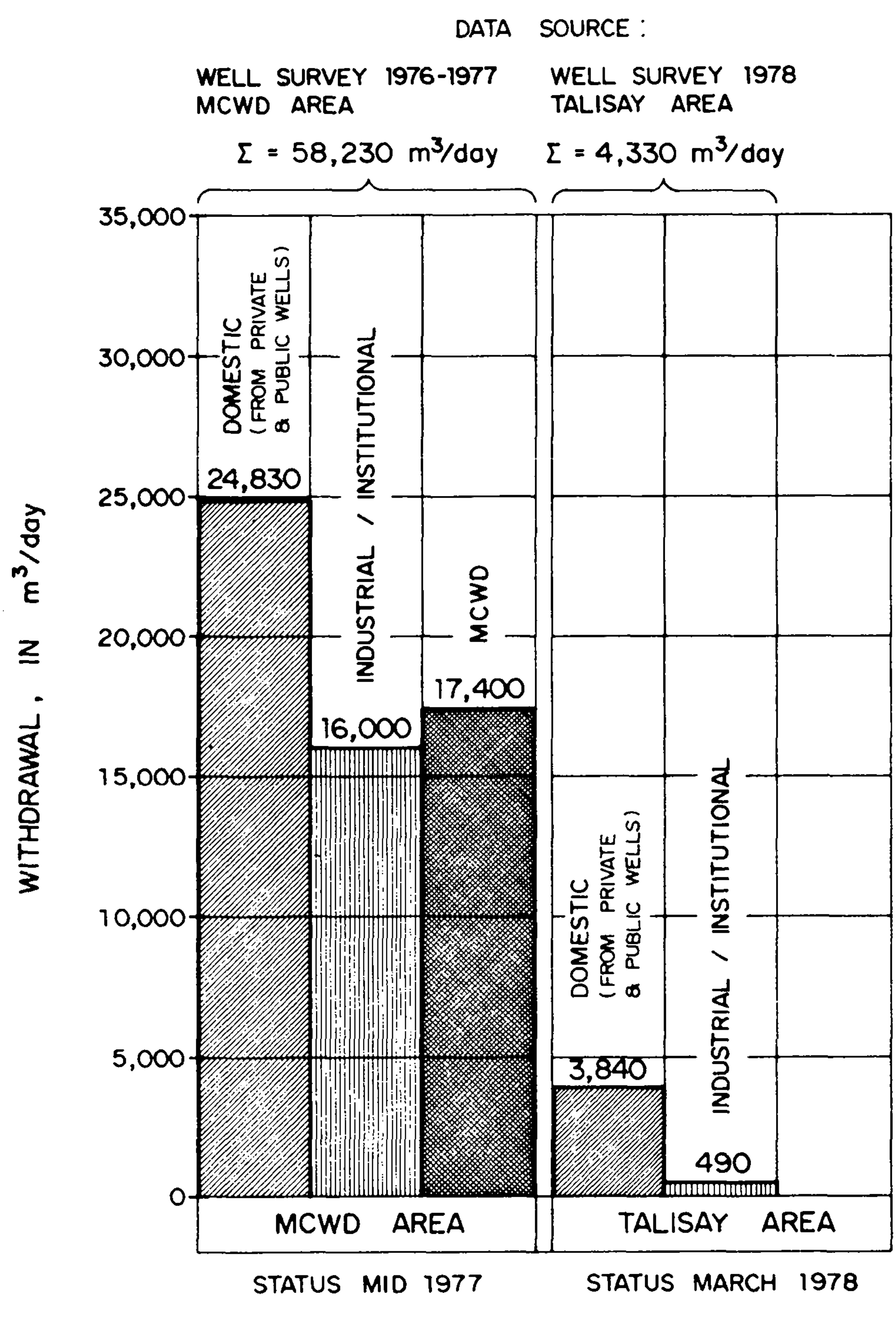


Fig. 4 Groundwater withdrawal 1977/78, MCWD area.

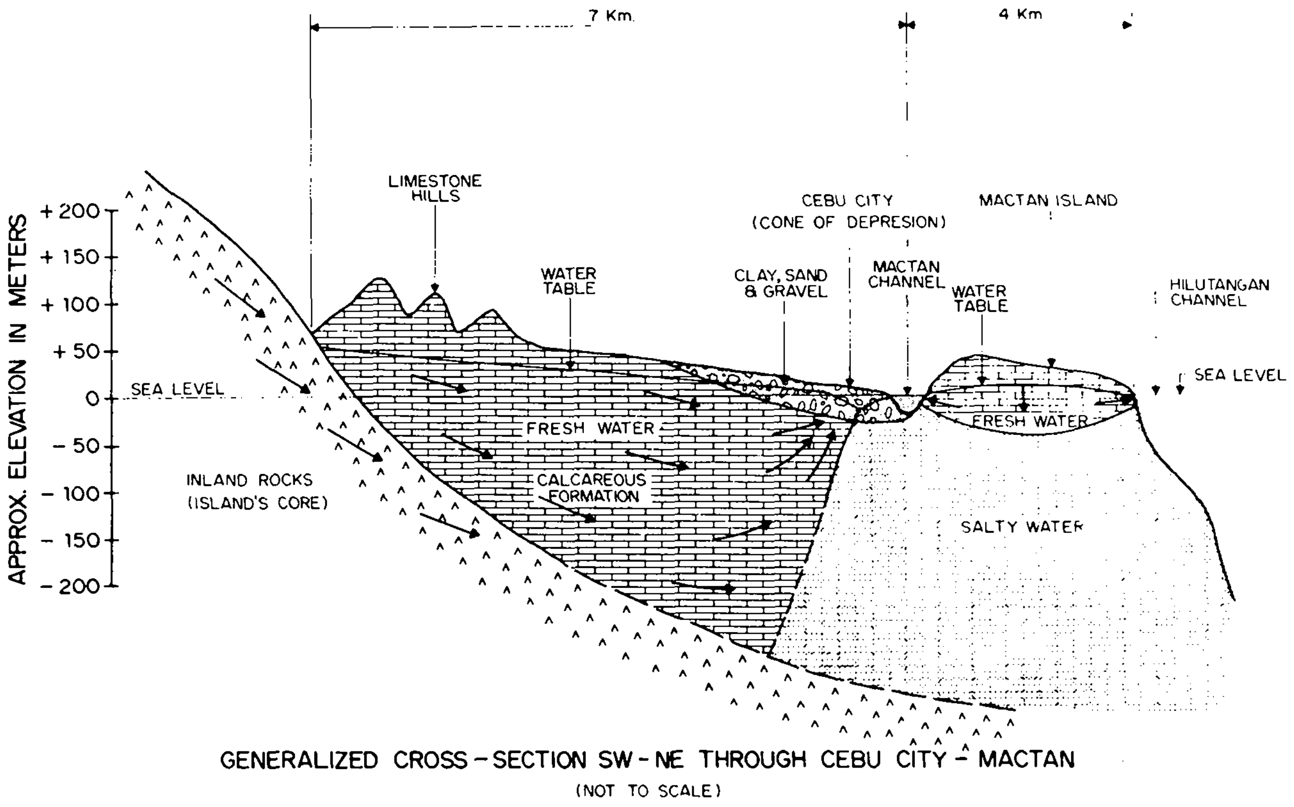


Fig. 5 Generalized cross-section in areas og withdrawal, MCWD area.

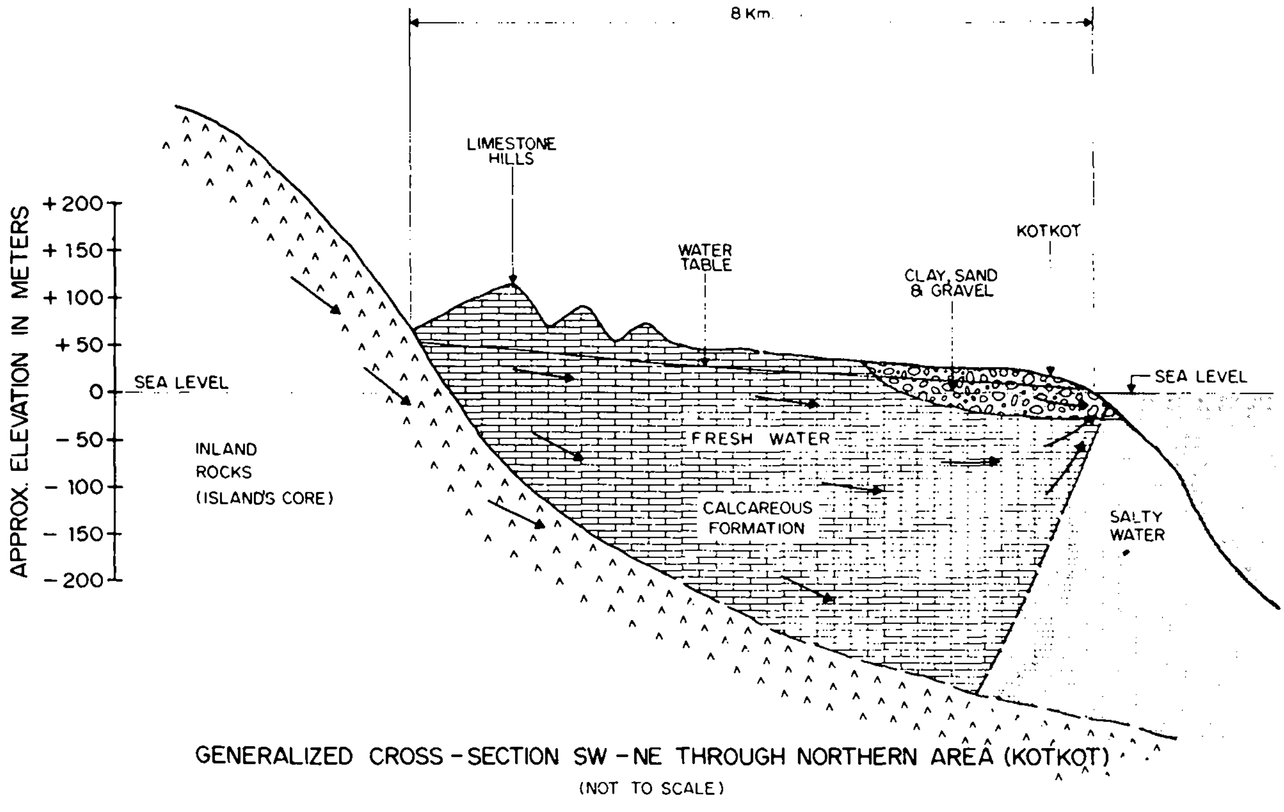


Fig. 6 Generalized cross-section outside of areas of withdrawal, MCWD area.

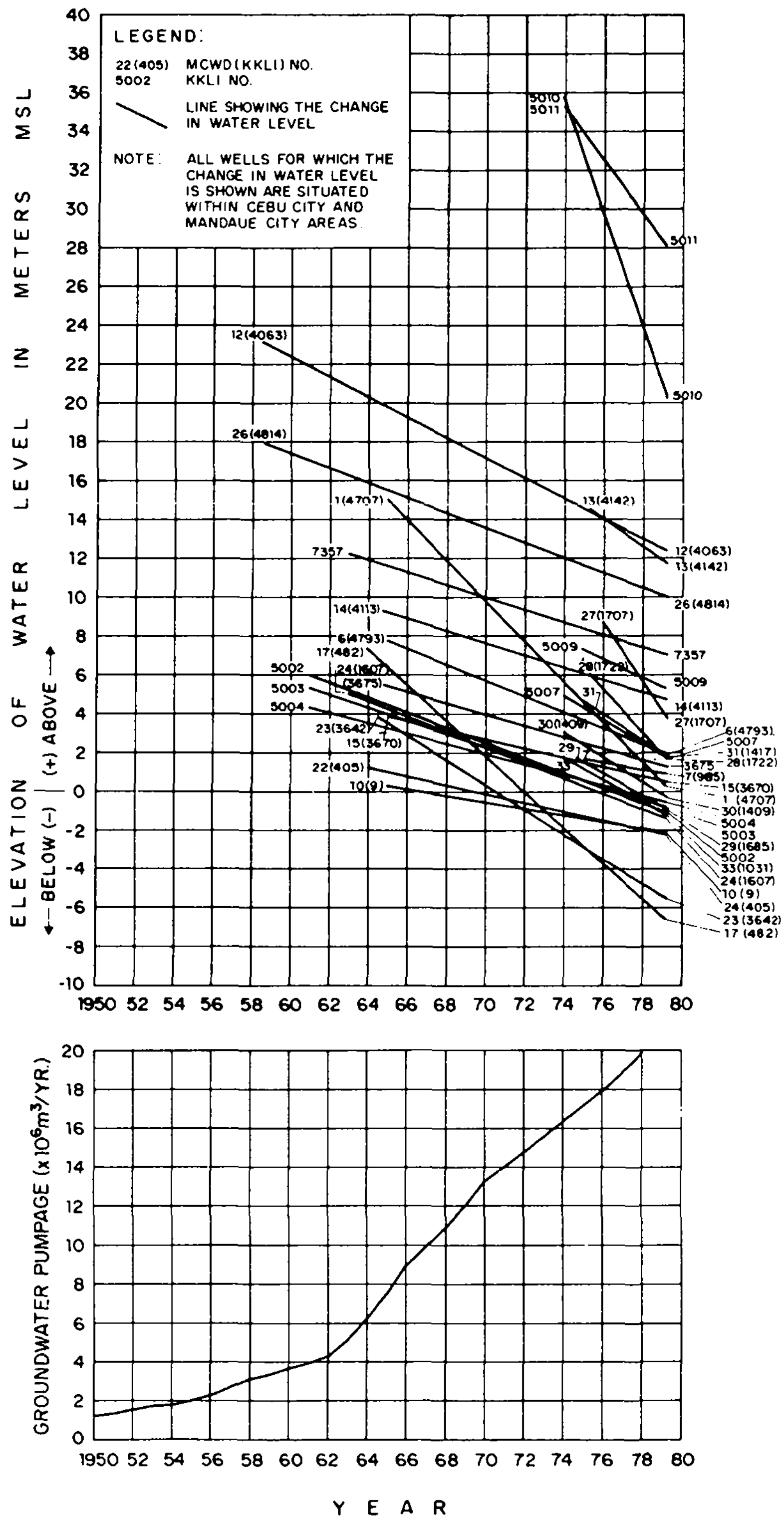


Fig. 7 Water level changes since 1958 and withdrawal of groundwater since 1950, MCWD area.

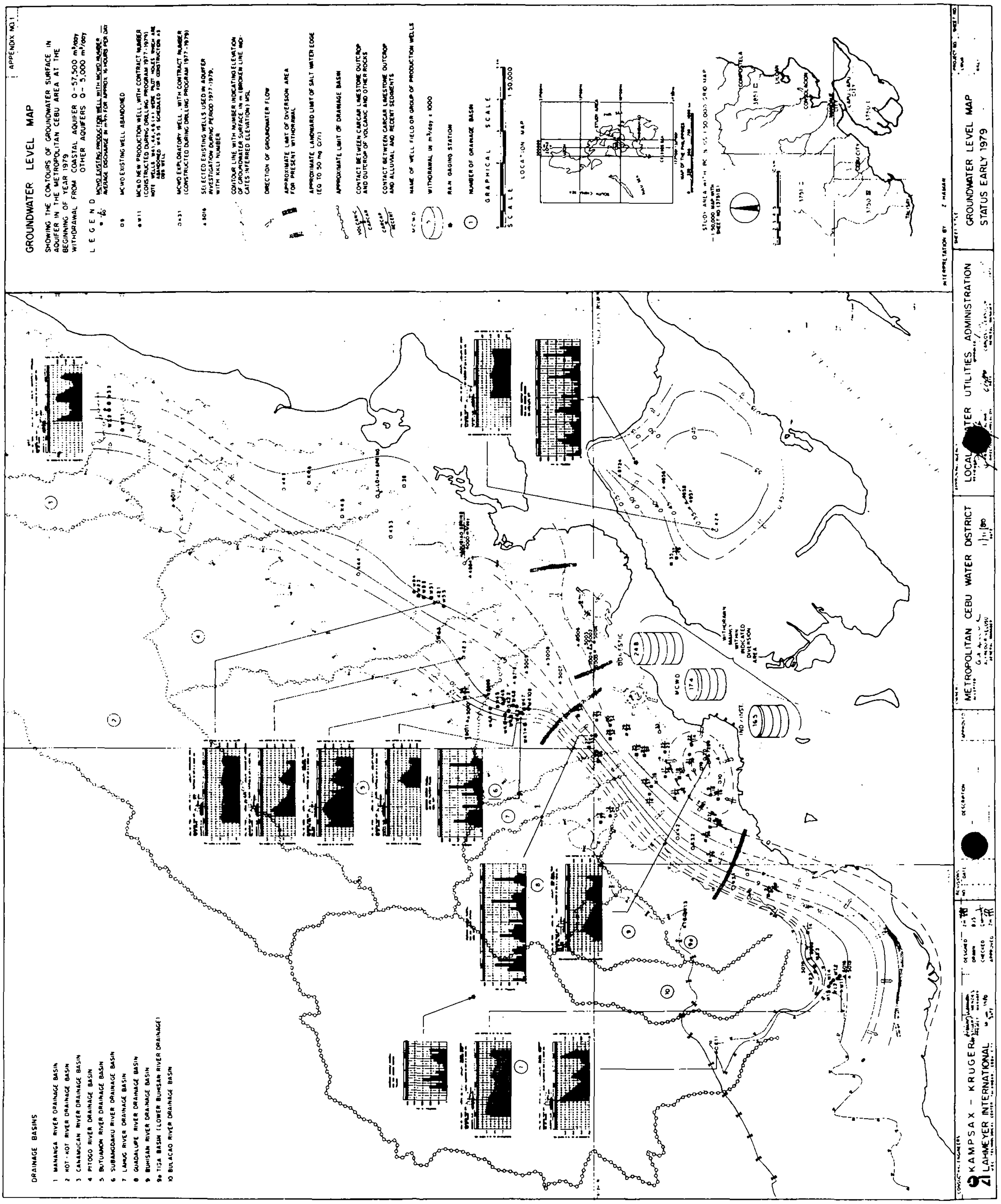


Fig. 8 Water level map (1979), discharge of MCWD wells, withdrawal per consumer category, static water level, rainfall, 50 mg Cl/l Izoline (1976), MCWD area.

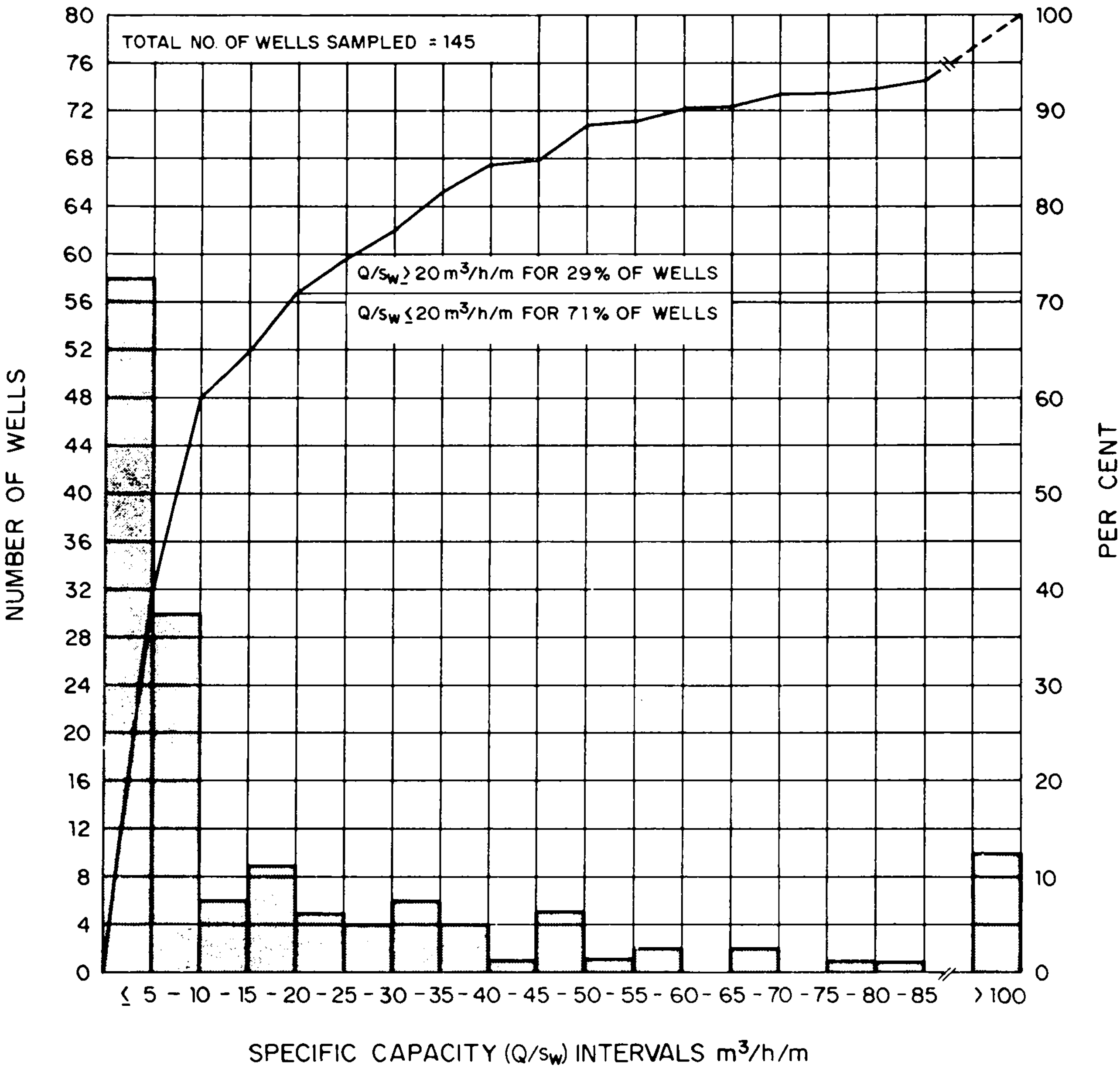


Fig. 9 Distribution of the specific capacities for selected existing wells in MCWD area.

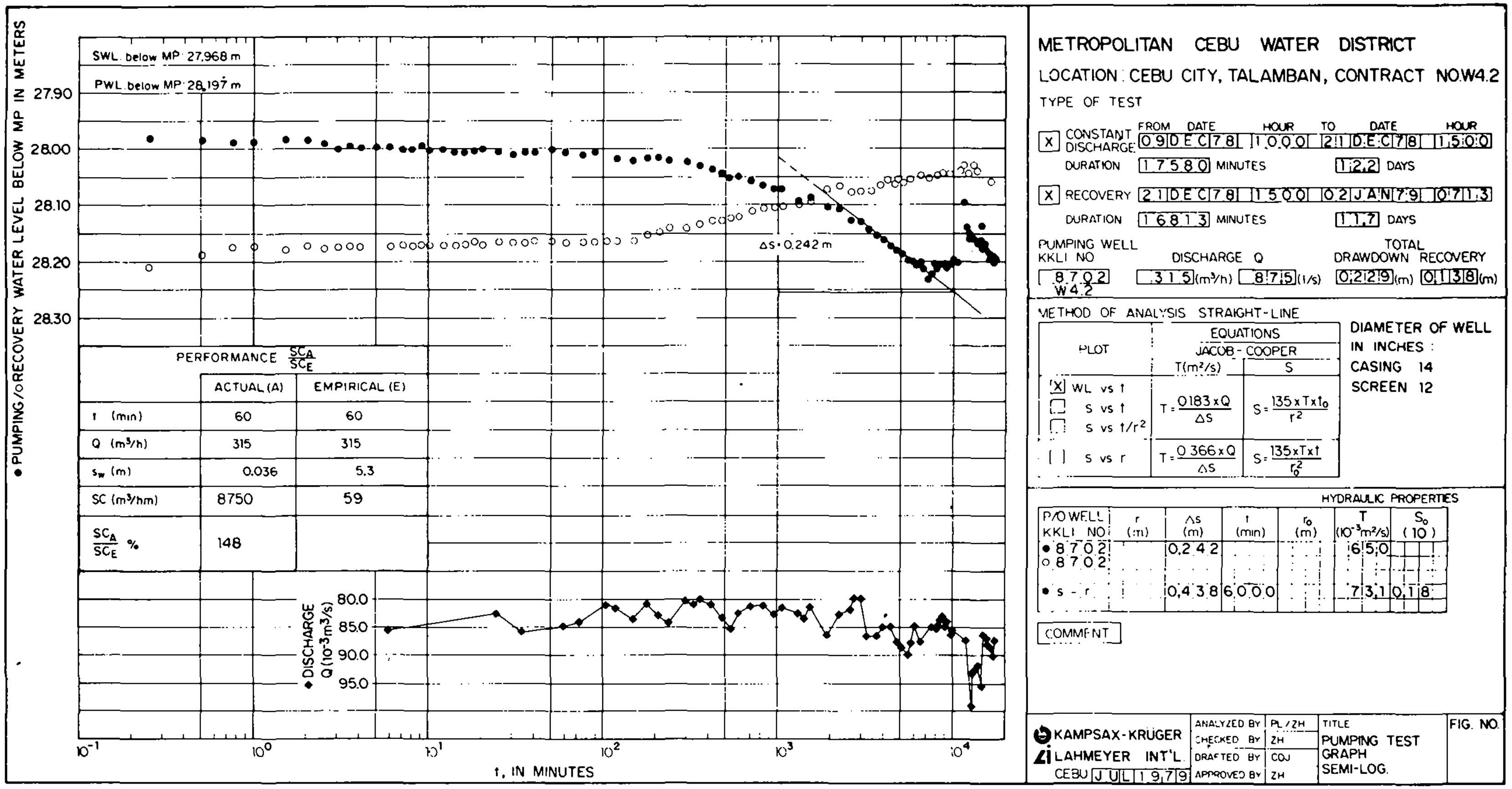


Fig. 10 Typical time-water level graph for well showing double-porosity effect, Talamban well field, MCWD area.

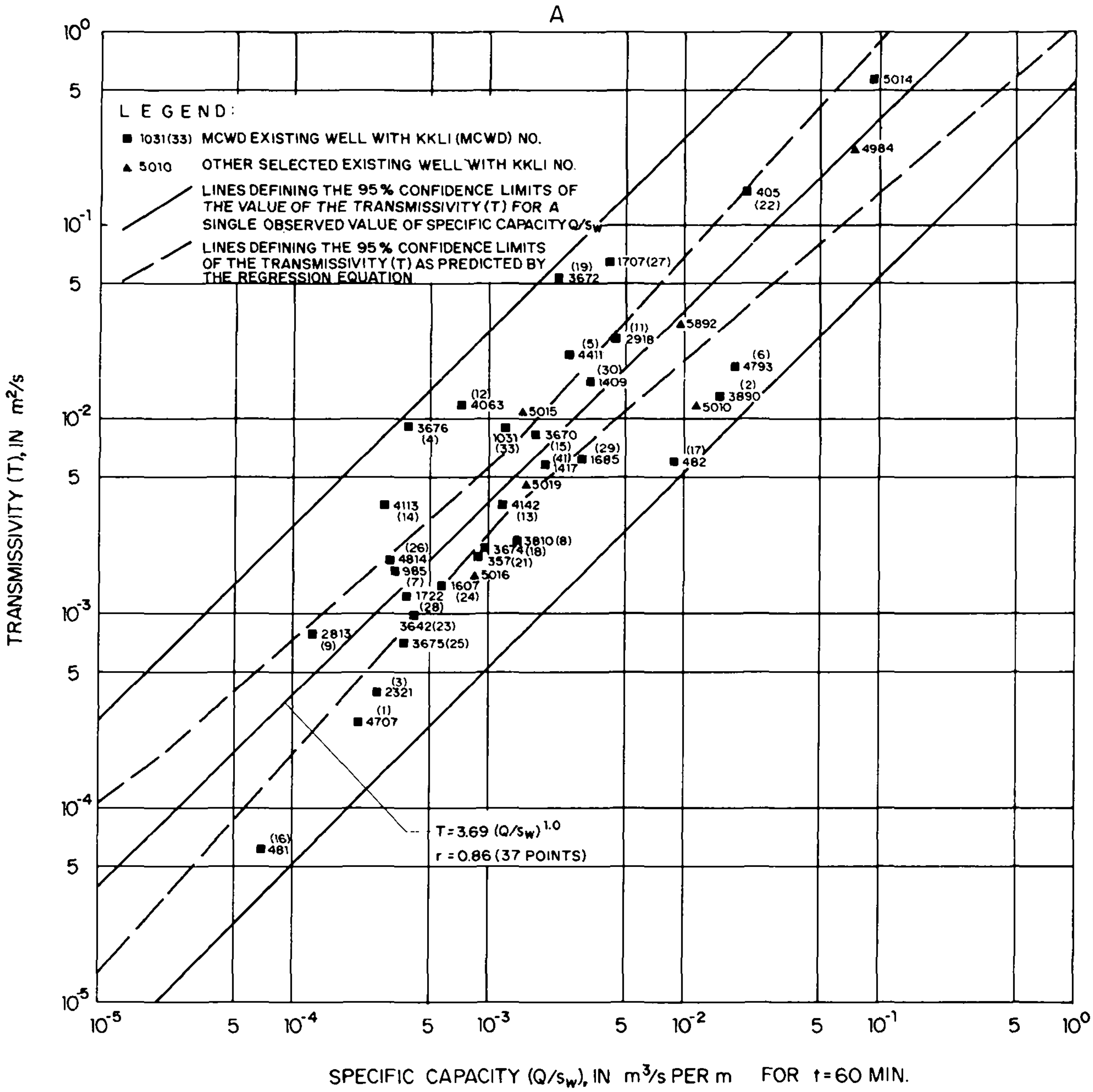


Fig. 11 T versus Q/s_w plot for old wells. t = 60 min., MCWD area.

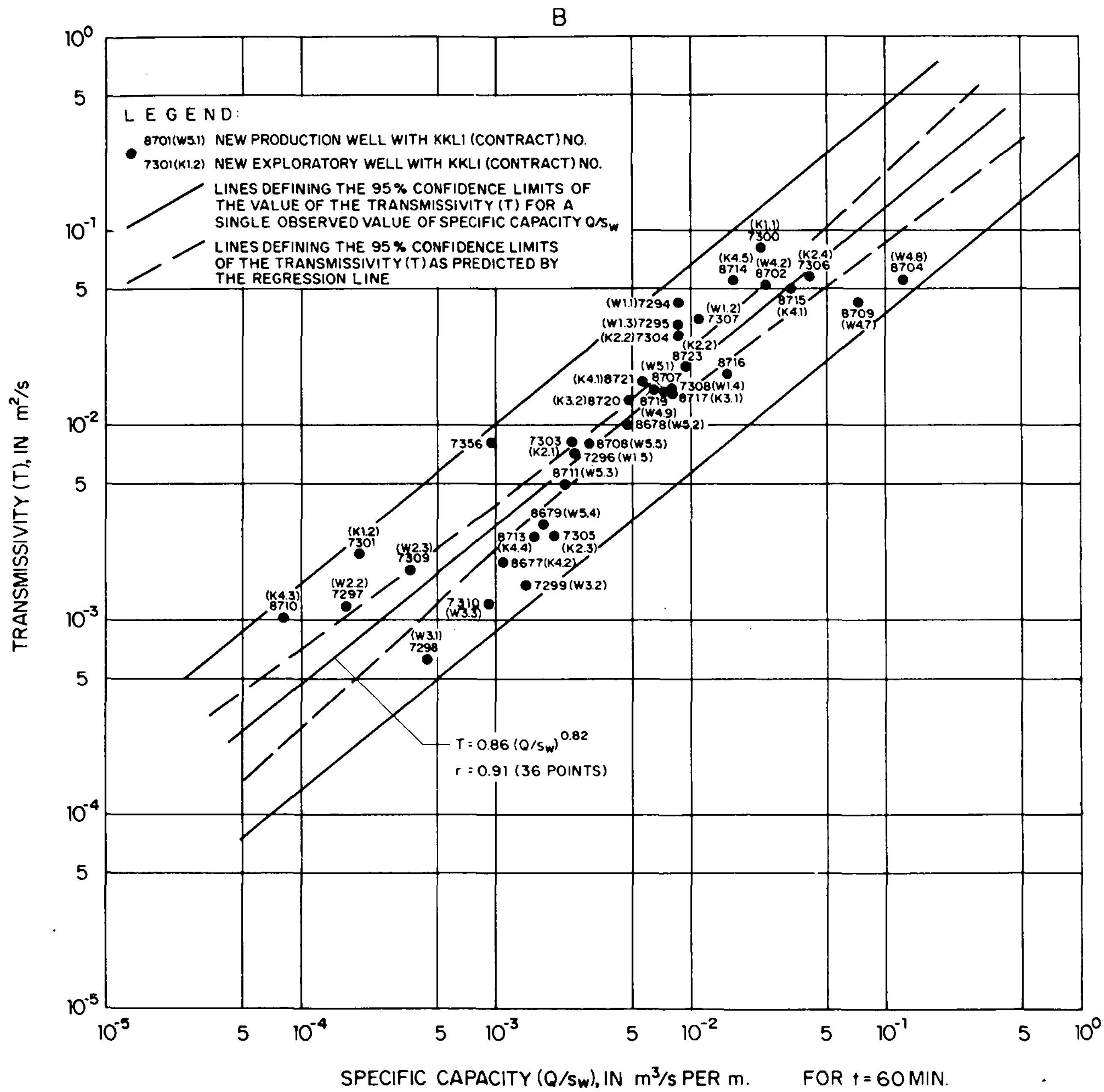


Fig. 12 T versus Q/s_W plot for new wells drilled during 1977-1979. t = 60 min., MCWD area.

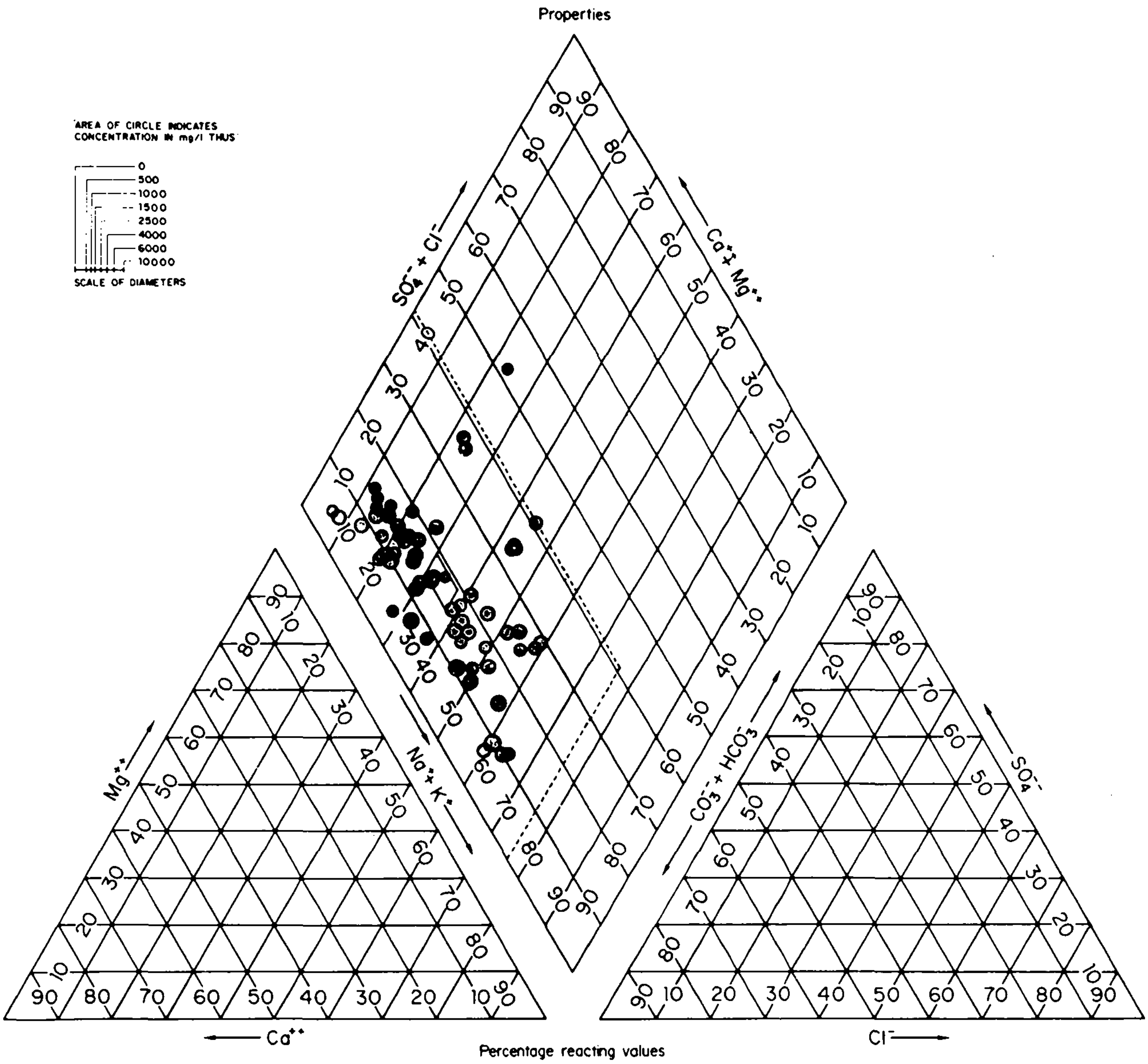


Fig. 13 Trilinear (piper) diagram, MCWD area.

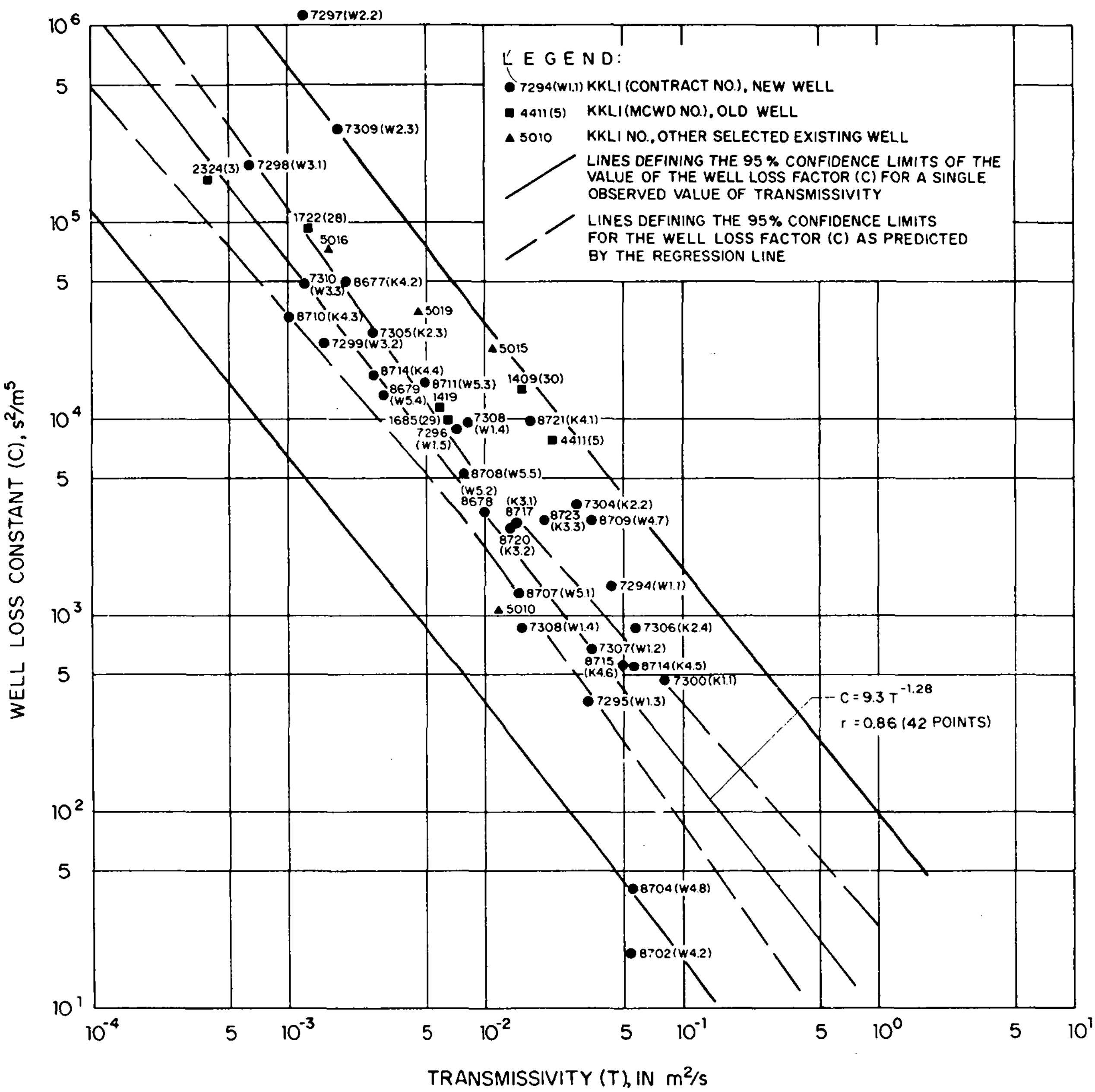


Fig. 14 Well loss constant (C) versus transmissivity (T) plot. Data from step-drawdown tests, MCWD area.

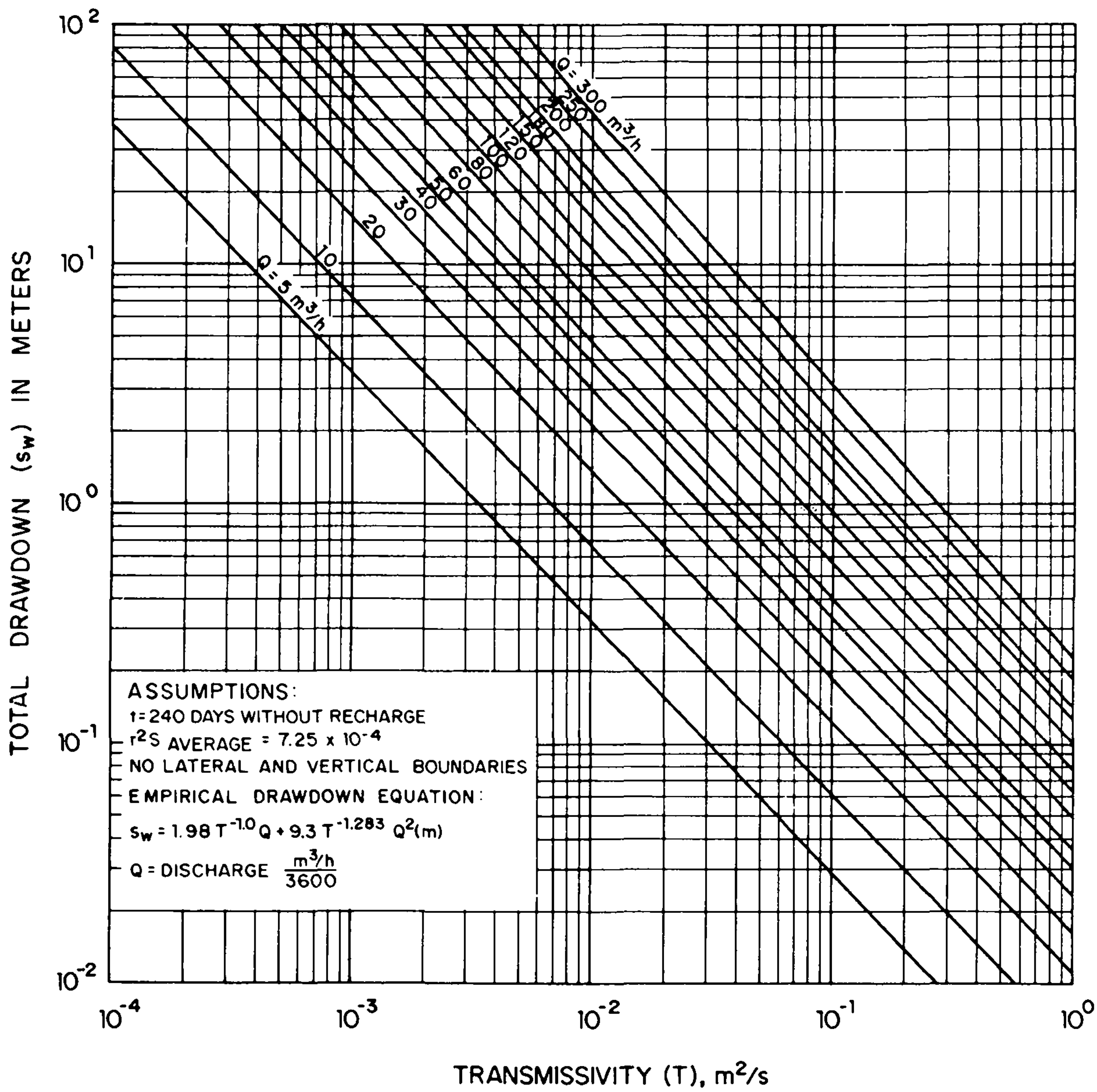


Fig. 15 Graph showing expected drawdown for different values of discharge and transmissivity. Pumping period 240 days, MCWD area.

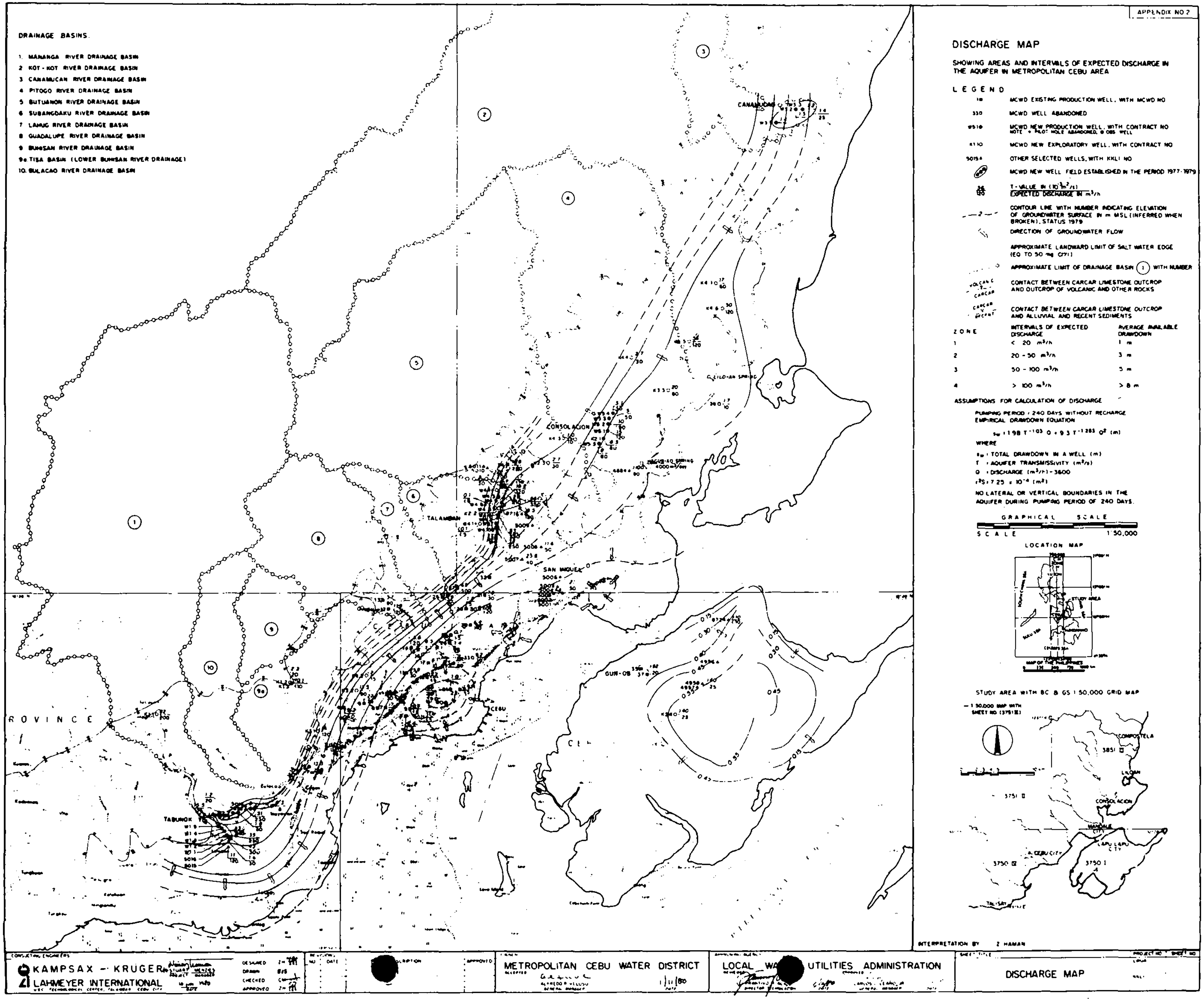


Fig. 16 Discharge map, MCWD area.

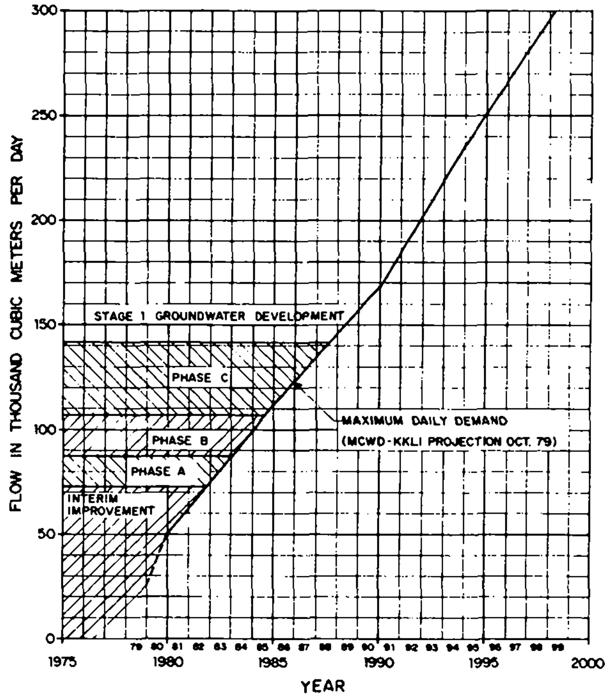


Fig. 17 Projected MCWD water demand and phases of groundwater development.

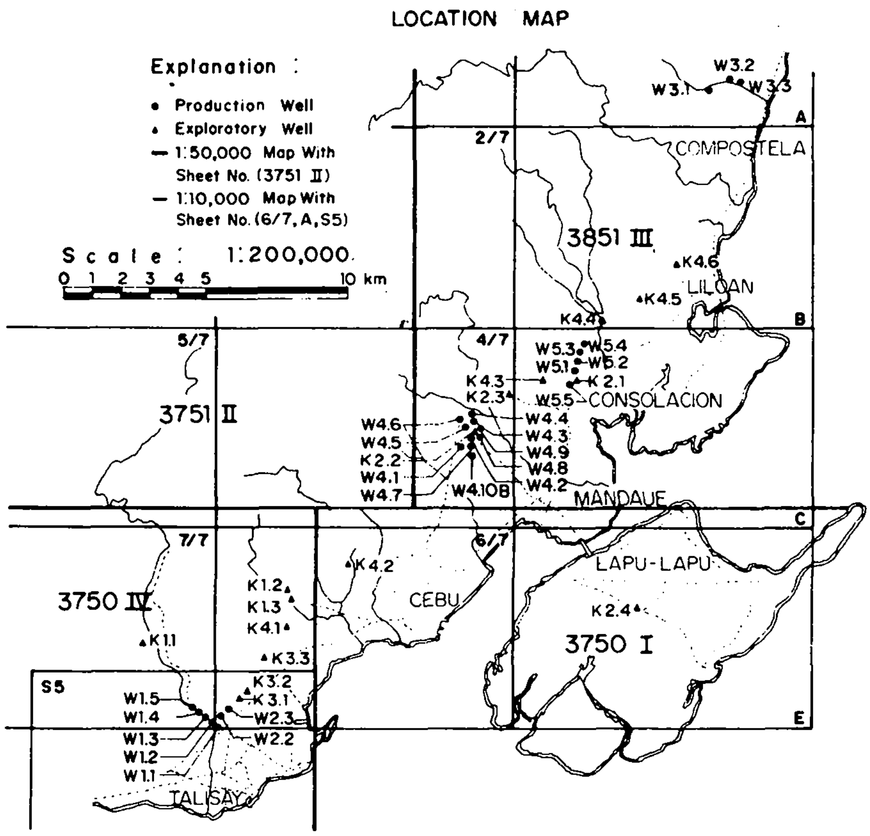


Fig. 18 Map showing location of exploratory/ production wells in the MCWD area.

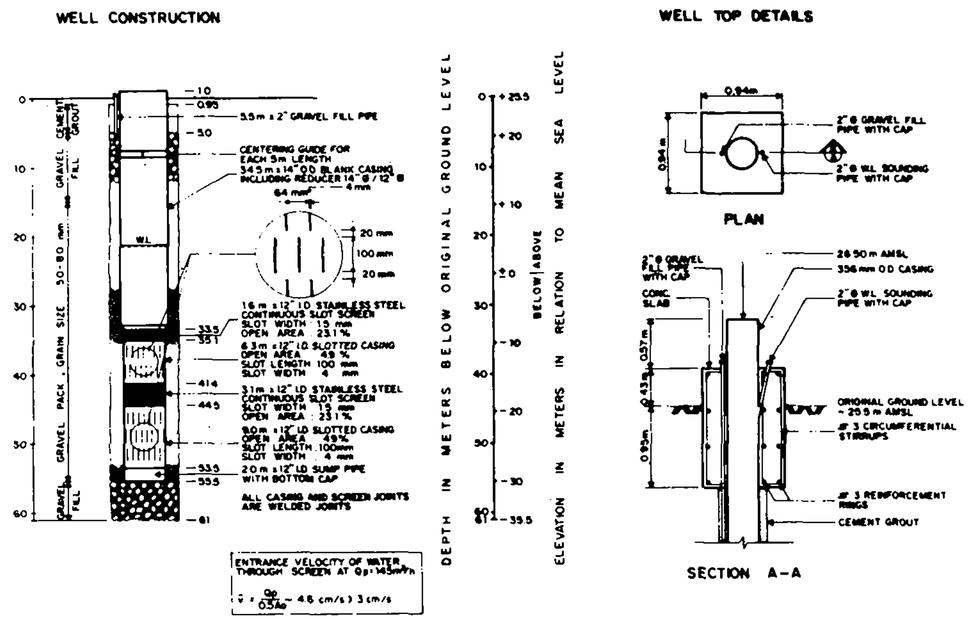


Fig. 19b Typical design of production well, MCWD area.

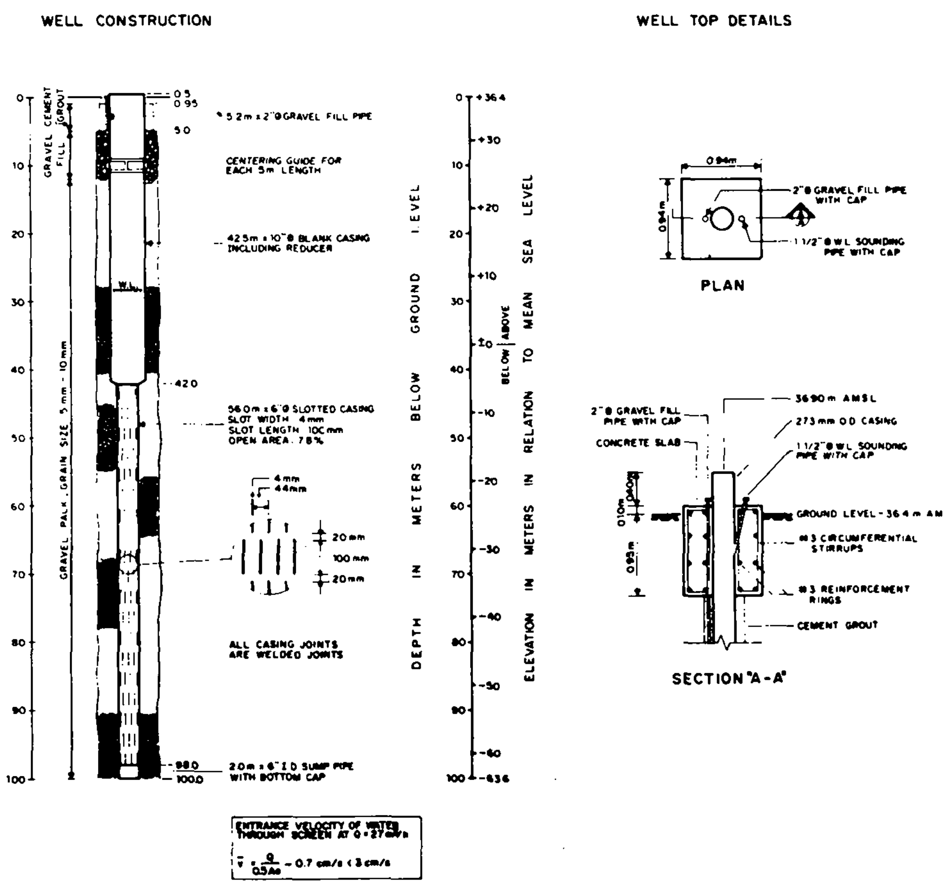


Fig. 19a Typical design of exploratory well, MCWD area.

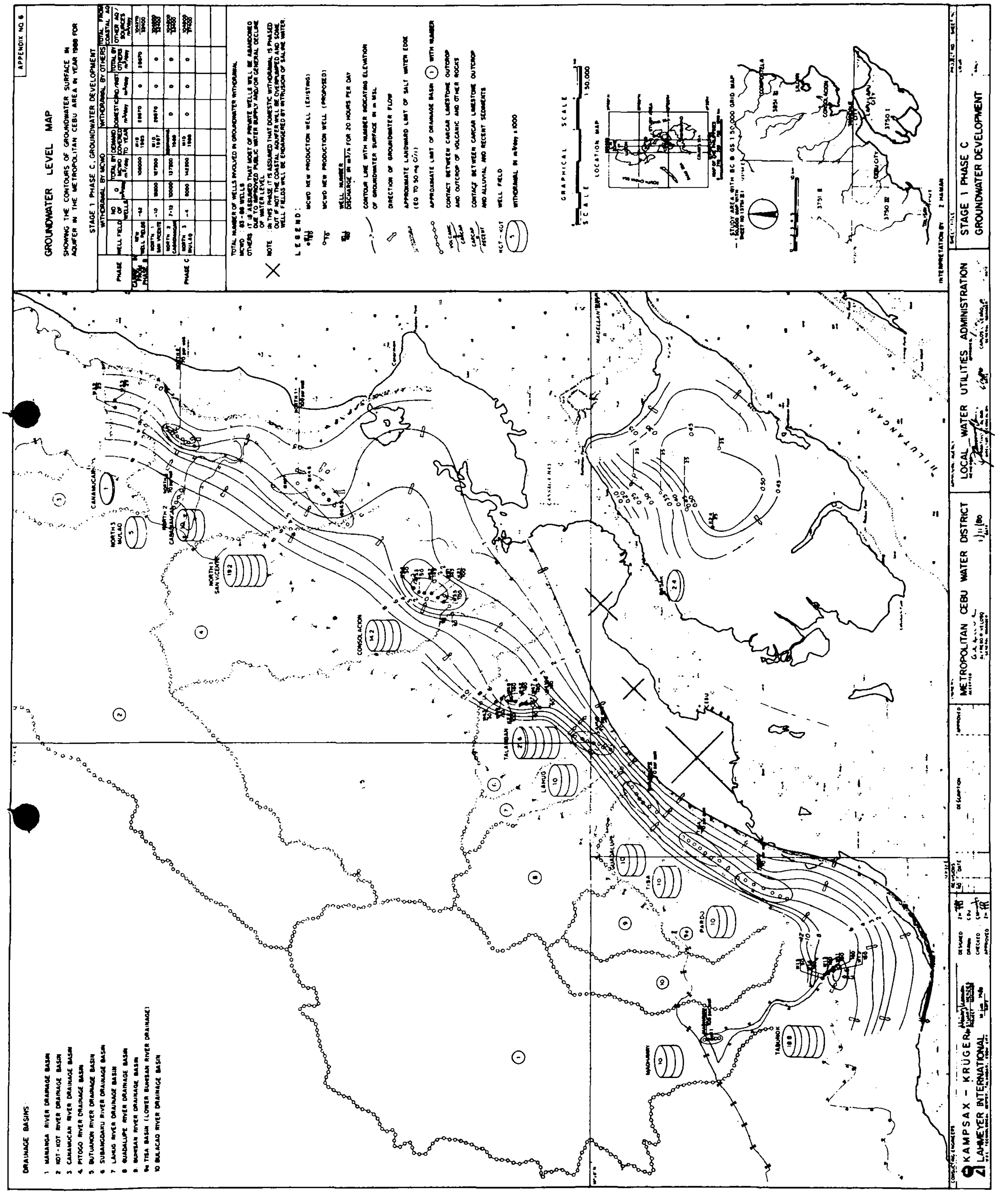


Fig. 20 Groundwater withdrawal and water level (projection 1988), MCWD area.

MANILA WATER SUPPLY III 1987-1998

by MARCIAL O. MANALAYSAY

Assistant General Manager for Engineering
Metropolitan Waterworks & Sewerage System
Philippines

Foreword:

In many developing countries investment in water had rated relatively low in the totem pole of their development programs, past and present. Man himself has taken water too much for granted. This, inspite of his repeated avowals that water is one of the four most basic of human needs.

Neglected thru the years, the global scenario is starkly appalling. As culled from United Nations (UN) sources only 38% of the 2 billion that people the developing world and only 22% of the world's rural population have easy access to safe water. Worser still, in the area of sanitation, only 15% of the earth's rural people have sanitation facilities. WHO sources say that 80% of all human diseases are water related. The toll is staggering: 13 million children under five die of water borne diseases each year.

The Philippine situation is only slightly better. As of 1980, 43% of total Philippine population have access to safe water supply.

Urbanized areas of the Philippines are much better off, with 53% access. But even the Greater Manila Area (GMA) leaves much to be desired.

Man has apparently not addressed the problem squarely.

Appalled at the dimensions of this global problem the United Nations proclaimed the 1980's as the "Water Decade." The UN objective is to provide safe dirnking water and adequate sanitation FOR ALL by 1990.

The World Bank estimates that $140 billion are needed to meet the goals of the water decade. This is four times than what the developing countries are spending today. The cost to meet the backlog is truly staggering.

The current Philippine scenario is more promising. As opposed to yesterday's apathy, water now occupies the forefront of our national planning strategies. This was given meaning and direction by no less than the First Lady of our land when she beautifully articulated that there are eleven basic needs in the whole spectrum that make up for a better quality of life for the humane man. And that of the eleven, water top ranks them all.

As an off-shoot of these new directions, the Philippines has recently created permanent water agencies with specific delineation of areal responsibilities; all with the ultimate aim of bringing this precious commodity down to the remotest rural *tao* and to his city counterpart – the "urban poor."

For its part, the Metropolitan Waterworks and Sewerage System (MWSS) has already developed a Greater Manila Water Plan. This Plan more than echoes the UN slogan. Its planning horizons embrace not only the balance of the century, but even looks forward 50 years beyond.

The rationale of the MWSS Plan can be better appreciated when viewed in the light of the following:

- o The Greater Manila area is one of the largest megalopolies in the world comprising the 4 cities and 13 municipalities of Metro Manila plus one other adjoining city and 10 suburban towns.
- o Compressed in an area of 150,000 hectares it is inhabited by a 6.53 million people according to the results of the recently concluded 1980 census.
- o The population of GMA has been increasing at the rate of 4.1% per year with population expected to reach 12.8 million by the year 2000.
- o Existing supply in GMA is lagging by 100 million gallons per day (mgd). In the meantime water demand is growing at an annual growth rate of 6.4% with demand expected to reach 560 mgd by 1986 and 1300 mgd by year 2000. From year 2000 growth rate is expected to decline down to 1% in the 2040-2050 decade.

Manila Water II

Our on-going water supply expansion program, Manila Water II, aims to increase system plant capacity from 360 mgd to 660 mgd and will cost P3.5 million by the time it goes into full stream by 1982/1983.

With almost all project components already in various stages of award and construction, progress in Manila Water II has now come to a point where we believe we can meet the following major milestones:

Already completed and placed into partial operation last May 1981 is a giant 3.4 meter diameter aqueduct. As a result we were able to stave off a planned, long-term cut back in normal supply this year.

The real, first major impact of the project will, however, be felt by November/December also of this year with the partial completion, by one half capacity, of a 400 mgd water treatment plant and a 3.0 meter diameter treated water main from Novaliches, Quezon City to Caloocan City. This will effect the first major (although partial) link of the new source to the existing Manila system;

By the end of 1982 the new water treatment plant will be fully operational, and completed will be a new dam at Ipo and a fourth turbine at the Angat dam all of which will, together, increase total MWSS system capacity to a maximum of 660 mgd. Daily deliveries will, however, average 560 mgd; and

By end of 1983, all other support facilities (pump stations; other mains) will be operational and the balance of the distribution system will be laid out.

With the target dates for the completion of the source-treatment-transmission works already thus known with confidence we have thus prepared the fourth stage – the vigorous execution of the laying of the distribution pipelines under a three-year construction period as conceived in a network master plan of the Greater Manila Area. We started pipelaying in a modest scale in 1980 and early this year. Pipelaying construction will, however, begin gathering momentum within the next few months, and will peak all through 1982 with the balance of the system to be completed in the early part of 1983. By the end of our program we will have laid about 1500 kilometers of new and replacement pipes that will carry water to the front yards of virtually every home in Metro Manila.

For Manila Water II the strategies had been to opt for the most cost-effective and least-cost, innovative solutions. Using these approaches many million pesos in savings have so far been effected in a number of specific instances. Examples include:

- o A higher dam as opposed to the alternative of tunnel enlargement;
- o Route selection of a new 3.4 meter aqueduct;
- o The use of prestressed, non-reinforced concrete pipe as opposed to a conventional poured-in place concrete aqueduct;
- o The use of new pipes employing the latest state of the art in the field of raw materials and pipe fabrication;
- o The adoption of declining rate filtration and other low-mechanical equipment process (treatment) technology; and
- o The use of very large diameter mains (and therefore less booster pumping) to achieve large reduction in power costs.

Manila Water Supply III

We are planning ahead for our next water supply plant additions because the water project now on-going and due for completion in 1982/83 is capable of meeting only the backlog of the 1970's plus the increase in the demand until 1986/1987.

Completion of this current water project would bring total available supply of the entire MWSS System to a total daily average delivery of about 560 million gallons of potable water for residential, commercial and industrial uses. This represents an increase of 63% in water supply over current service deliveries of only 350 mgd. Cost of the project is over three and one half billion pesos.

However, the total supply, including the on-going system expansion, can meet the growing demand only up to year 1986/1987, by the most optimistic estimates. Other independent estimates indicated that shortages come even earlier.

Furthermore, sometime towards the middle of this decade, large new demands would be imposed on the MWSS system in the form of substantial water requirements for new political subdivisions which had recently been added to MWSS service area and new, organized subdivisions rapidly sprouting up in the satellite cities of Manila.

What is significant is that if nothing is done now to plan for, and thenceforth to implement an additional major source of water supply, the resulting shortage in the MWSS Central Distribution System will be in the neighborhood of about 200 Million gallons per day by 1990 or about 25% of the projected demand by that time. Thus, a large major source of water supply must be developed by about 1987 – paving the way for Manila Water Supply III.

In order to appreciate in total perspective the Manila Water Supply III, it would be opportune to retrace the beginnings of the project.

On August 6, 1976, after having been appraised of the need to develop a new water supply source after the full utilization of the Angat Reservoir allocation of MWSS, the President of the Philippines issued Memorandum Order No. 569 creating an inter-agency committee charged with the re-appraisal of the Marikina River Multi-Purpose Project. The committee was composed of the heads of the following agencies: Metropolitan Waterworks & Sewerage System, National Economic & Development Authority, National Power Corporation, National Water Resources Council, Bureau of Public Works, and Department of Public Works, Transportation & Communications. The General Manager of MWSS was designated Chairman of the Inter-Agency Committee.

The Inter-Agency Committee, in turn, formed a Joint Technical Committee (JTC) with the objective of studying the Marikina River Basin since at the time it showed a-priori potential as the possible next major source of water supply and other multi-purpose uses for Metro-Manila.

The Joint Technical Committee prepared a pre-feasibility report on the Marikina River Multi-Purpose Project which became the basis for carrying on with the subsequent feasibility study. The study indicated a need for revising the project objectives by zeroing in only on the water supply, power potential and flood mitigation aspects of the project, but sans irrigation. A new look into the design concept from the original concrete high arch dam to a rockfill dam was also recommended.

In November 1978, the Marikina study was expanded to cover other alternative, or combination of alternative, sources of water supply comparatively viable, if not better than the Marikina River Basin.

Eight (8) other potential water resources near Metro Manila were investigated concurrently, namely:

- o Kaliwa River in Tanay, Rizal;
- o Kanan River in Infanta, Quezon Province;
- o Umiray River in Umiray, Quezon Province;
- o Laguna Lake, Laguna de Bay
- o Marikina Valley in Rizal (for Ground Water);
- o Calamba-Sta. Rosa Area in Laguna (also for Ground Water);
- o Tagaytay Lake, Batangas; and
- o Pampanga River to be tapped near Arayat, Pampanga.

Metropolitan Manila is one of the megalopolies in the world that is blessed with potentials for these large, pristine mountain sources of water supply that could take care of its demand up to the year 2050 and even beyond. These sources are proximate to the city, relatively cheap, low-power consuming, and needs only a minimum amount of treatment. These sources will be reserved and preserved by our government for the future water supply and allied needs of Manila.

Studies of the nine (9) water resources established that Kaliwa River Basin as the most viable water resource as the next major source of water supply in the water development program of MWSS, now denominated as Manila Water Supply III.

The President approved the Kaliwa Project Alternative.

In August 1979, a World Bank Mission (on hand to appraise the sewerage/sanitation project of MWSS) recognized the importance of forward planning for a new water supply source next to Angat River. It agreed to recommend to the bank financial support for the detailed design of the project.

With the approval of the Kaliwa River Basin as the next immediate supply source in its expansion program MWSS formally took over from the Presidential Inter-Agency Committee responsible charge of the implementation of Manila Water Supply III on March 1, 1980.

For convenience in identification, the Manila Water Supply III is divided into three (3) major components: (1) The Headworks (dam and intake works); (2) The Water Supply Treatment and Power Works; and (3) The Distribution System.

The Headworks consists of:

1. A 113 meters high rockfill dam with vertical clay core located at Laiban on the Kaliwa River. Dam volume is about 9.7 million cubic meters.
2. Spillway with a design discharge of about 2,800 cubic meters per second.
3. Reservoir with a live storage of about 500 million cubic meters.
4. Pressure tunnels between 3.1 to 3.3 meters in diameter for a total length of about 1 kilometer.
5. Pipelines between 2.7 to 3.0 meters in diameter for a total length of about 5.7 kilometers.

The water supply/power works include the following structures:

1. Water Treatment Plant at Pantay, Antipolo, Rizal with a capacity of 28 cubic meters per second (or about 640 million gallons per day).
2. Power station also at Pantay, Antipolo with an installed capacity of 21 megawatts.

The distribution system includes the following items:

1. Treated water storage tank located near Cogeo Village, Antipolo, Rizal, with a capacity of 300,000 cubic meters.
2. Primary distribution network composed

of 0.30 to 3.9 meters diameter pipelines with a total length of approximately 307 kilometers and 8 regulating storage tanks dispersed around Metro Manila with a joint capacity of about 279,000 cubic meters.

3. Secondary distribution network consisting of 10 to 25 centimeters diameter pipelines for a total length of about 1,010 kilometers.

4. Tertiary distribution network consisting of 5 to 7.5 centimeters diameter pipelines for a total length of about 250 kilometers; 700,000 domestic service connections; 52,000 industrial-commercial-institutional service connections; 4,300 fire hydrants; and required branch offices.

5. Water supply works from the Water Treatment Plant at Pantay to Lungsod Silangan Module I.

The overall concept of Manila Water Supply III considers the future integration of Kanan River Basin, an adjacent watershed, under a trans-basin arrangement.

As a result of the study of nine (9) water resource potentials, a sequential development prioritization of water resources for Metro Manila was also evolved. After Kaliwa River Basin, Kanan River Basin with a potential yield of about 3,170 million liters per day (or 800 million gallons per day) is the next ranked project; followed next by Umiray River Basin with a potential yield of about 777 million liters per day (200 MGD), and/or Laguna de Bay with a potential yield of about 2590 million liters per day (680 MGD). The Marikina River with a potential yield of over 300 MGD remains a viable alternative but will have to be considered in the long term until technology has progressed to a point where public bias against the same has been sufficiently allayed. Much has to be done towards this end and the technologist must show convincing proof in a given time and clime. In the meantime the nation's development does not have all the waiting time.

Due to the proximity and orientation of Kanan River Basin in relation to the Kaliwa River Basin, an incremental development of merely a dam and diversion tunnel that could produce a relatively high yield was found very attractive. Moreover, this combination would facilitate supply of water to Lungsod Silangan Development Plans of the Government.

As planned,the Kaliwa River Development would provide a yield of 22.1 cubic meters per second (500 MGD) and should meet the projected growth of demand for public water supply from 1987 to 1998, while Kanan River Basin can take care of water requirements from 1998 up to year 2020.

The implementation of Manila Water Supply III would not pose unusual technical difficulties and there is no negative ecological or sociological implications, other than the dislocation of about 1000 families who are currently engaged in subsistence farming within the proposed reservoir area. The relocation problem is now being addressed by the government thru an inter-agency effort among which are the Ministry of Human Settlements, the Ministry of Agrarian Reform, Bureau of Forestry, Bureau of Lands, MWSS and others.

The estimated total investment cost of Manila Water Supply III, is about P6.0 billion at 1979 prices, but may reach P9.1 billion if escalated for inflation.

We expect to tap external currency loans in the amount of $548 million which is equivalent to 45% of the total project cost while the remaining 55% will have to be covered by local currency loans, additional equity and internal cash generations.

Manila Water Supply III has been planned with the construction program spread out over a 14-year period. The work schedules are synchronized with projected demand build-ups, with some flexibilities to meet possibilities of changed conditions within the duration of the long construction schedule.

Having obtained an engineering loan from Swiss transfer credits, the detailed engineering of MWSP III was started on July 1 of this year. Before this MWSS undertook pre-design activities mostly out of its own resources.

With the Manila Water Supply III on the threshold of implementation and all future sources of water supply already well identified and preliminarily prioritized MWSS now has the planning tools to face the future requirement of its client – population with a large amount of confidence. We have addressed our efforts during the last few years to this task so that in the future Metro Manilans need not see the likes of the unfortunate water shortages they are now suffering from.

As a part of the total effort, MWSS is improving not only its physical service delivery capabilities but also its institutional framework.

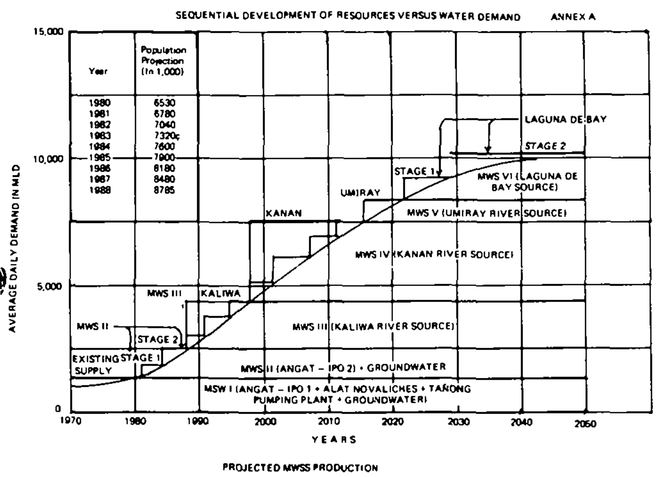
The Water Development Plan for Greater Manila will be sustained and continuous so that Metro Manila can live up to be truly a City of Man.

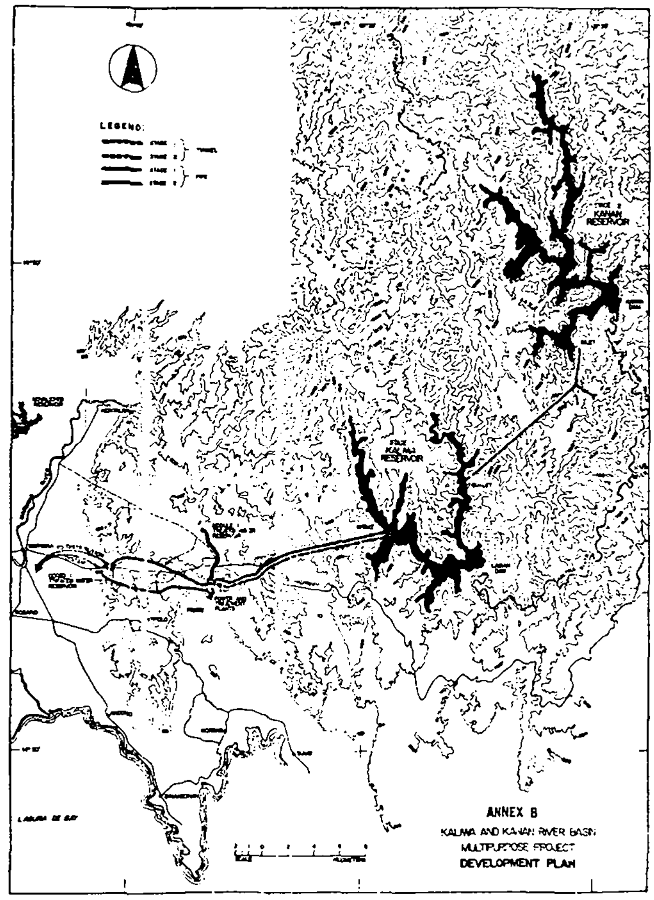
In parallel to this effort, the thrusts of all other water plans at national and rural levels call for more qualitative rather than just quantitative changes in the delivery levels of services.

This means that to serve the maximum number of our people at the shortest time, the peso must be stretched. This means, further, that we must convince the beneficiaries to accept lower standards of service in order to reduce unit costs;

that we must have to mobilize and maximize local community resources; that we must improve on, and be innovative in, the technical and financial performance of existing systems thru sustained maintenance and upkeep. The challenge is in planning ahead and in innovation. In a sense the UN slogan is a challenge to the Engineer.

This is how the Philippines is opting to make a meaningful contrbiution to the UN motivated goals in the attainment of the target of the decade.





ANNEX – C

MANILA WATER SUPPLY III
PROJECT WORK SCHEDULE

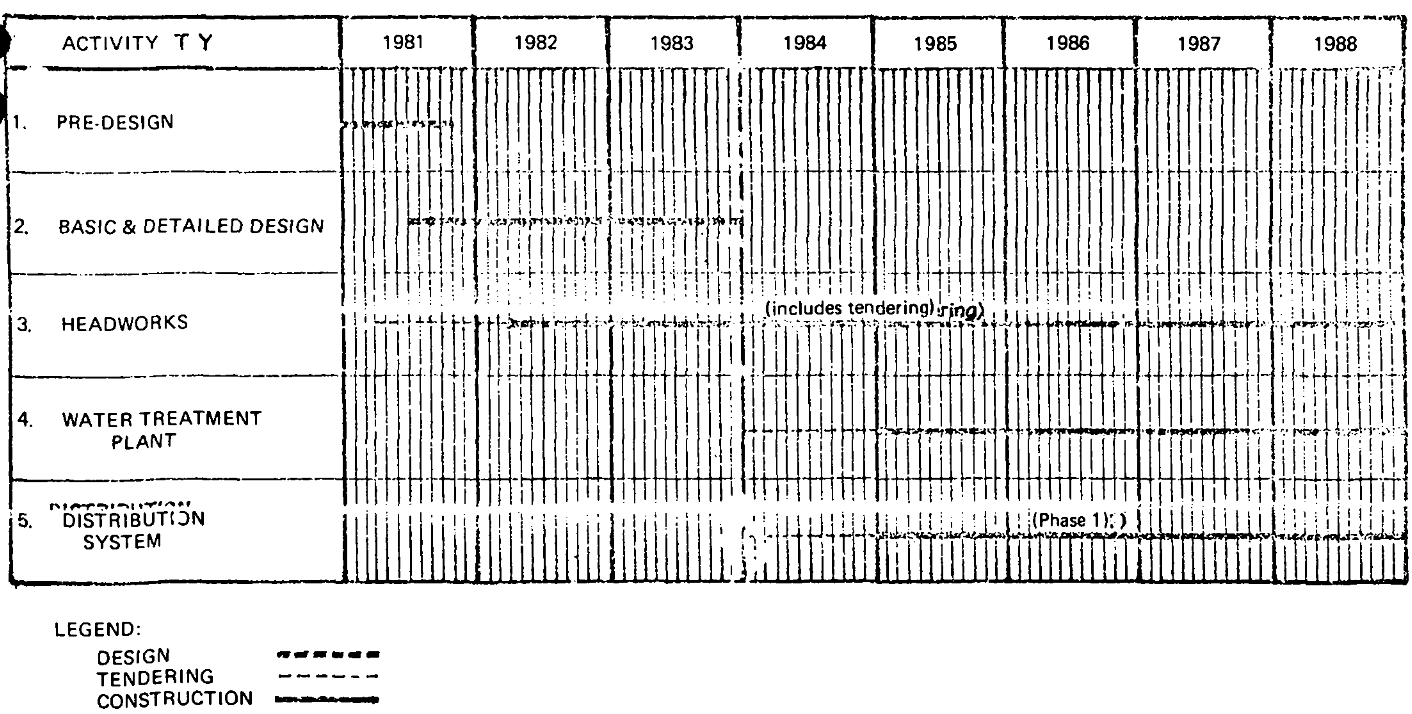
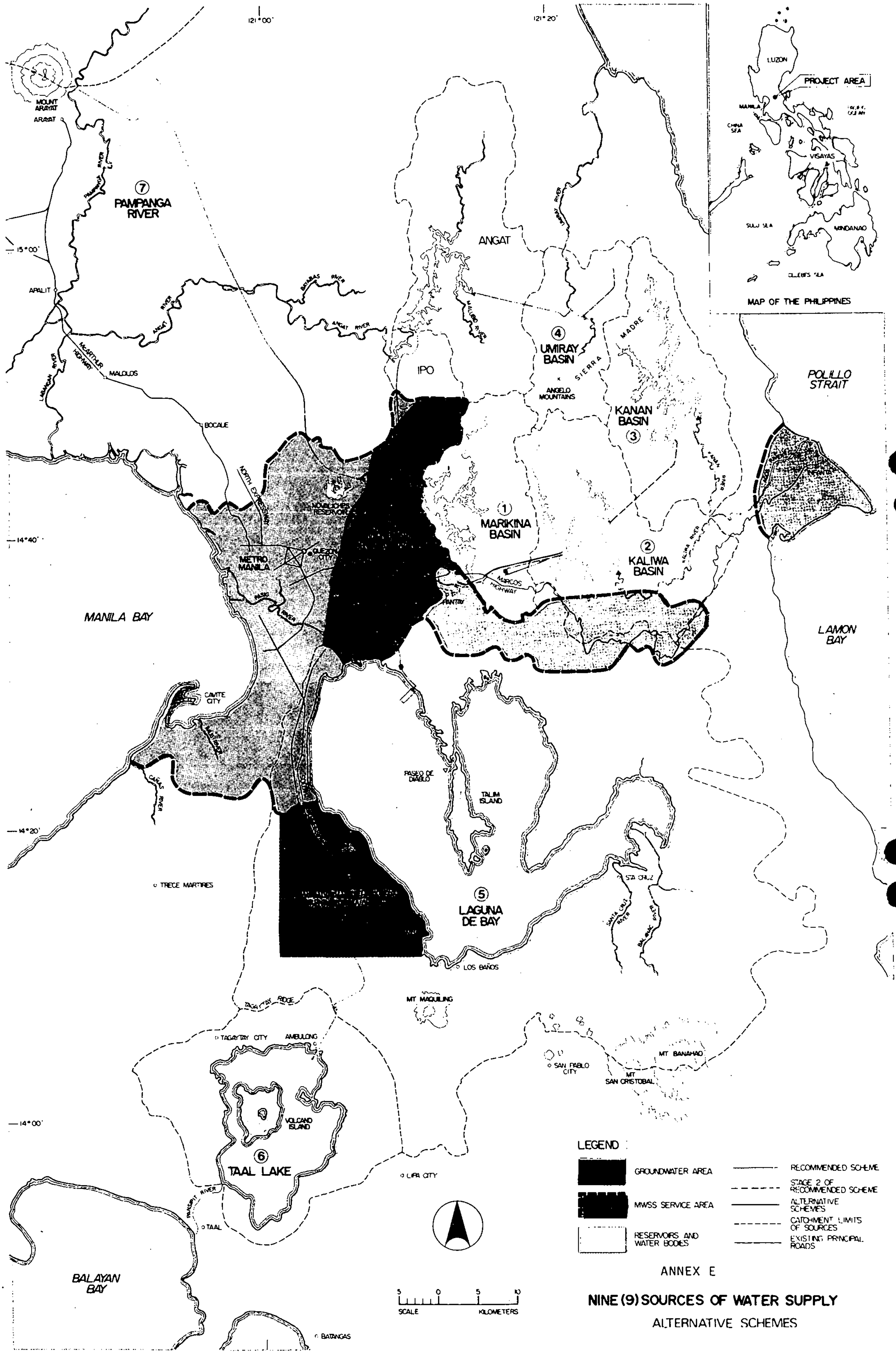


Table 1

SUMMARY DATA FOR MAIN FEATURES OF METRO MANILA WATER SUPPLY III PROJECT

HYDROLOGY	
Catchment Area	276 km^2
Mean discharge at Laiban damsite	25.2 m^3/s
Design Flood	4880 m^3/s
RESERVOIR	
Maximum pool elevation for regulation	270 mllw
Minimum pool elevation for regulation	235 mllw
Live Storage	500 x 10^6 m^3
WATER SUPPLY WORKS	
Laiban dam	Rockfill with central impervious core.
Crest elevation	281 mllw
Crest length	590 m
Maximum height	113 m
Volume of fill	9.7x 10^6 m^3
Spillway	Free overflow chute.
Crest elevation	270 mllw
Crest length	60 m
Maximum head on crest	8 m
Design discharge	2800 m^3/s
Outlet Works to Pantay Power Station	
Inlet	Single-level, gated concrete structure
Pressure Tunnel	Concrete-lined with surge chambers
diameter	3.3 m
length	9.3 km
Pipeline	3.0 m
diameter	3.0 m
length	4.3 km
Design discharge	28 m^3/s
Pantay Powerhouse	Concrete surface structure.
Installed capacity	2 x 10.5 MW Francis Turbines
Tailwater elevation	134.0 mllw
Pantay Water Treatment Plant	Conventional.
Capacity	28 m^3/s (2,400 Mld)
AGL at Outlet	125 mllw (140 MWSS datum)
Waterway to entry point to Primary Distribution System	
Pressure Tunnel	Concrete-lined ciruclar section.
diameter	3.1 m
length	6.7 km
Pipeline	Steel reinforced concrete.
diameter	2.7 m
lenth	1.1 km
Design discharge	25 m^3/s

Primary Distribution System	
Cogeo Treated Water Tank	Concrete surface structure
Capacity	306,000 m^3
Maximum HGL	100 mllw (110 MWSS datum)
Pipelines	
Range in diameter	300-3900 mm
Total length	307 km
Regulating Storage Tanks	
Number	8
Total Capacity	278,000
Secondary Distribution System	
Pipelines	
Range in pipe diameters	100-250 mm
Total length	1010 km
Tertiary Distrbiution System	
Pipelines	
Range in diameters	50-75 mm
Total length	250 km
Service connections and meters	
Domestic services	700,000 no.
Range in diameters	16-50 mm
Commercial, Industrial, Institituional Services	52,000 no.
Fire Hydrants	4,300 no.
Branch Offices	5 no.



ANNEX E

NINE (9) SOURCES OF WATER SUPPLY

ALTERNATIVE SCHEMES

WATER SUPPLY DEVELOPMENT IN GREATER TAIPEI AREA

by TENG-YUNG LAI

Commissioner, Taipei Water Department
City of Taipei
Republic of China

The population in Taipei region increased rapidly from 500,000 to more than 3,000,000 in the past 30 years. The population is expected to double by the year 2011. The growth of population combined with industrialization and improvement in living standard has led to a tremendous increase in water demand. Briefly presented in this paper are: A brief history of water supply development, how the rapid increase in water demand has been coped with, alternatives of Water Supply Development for the 4th stage long-range water supply plan, Feitsui Reservoir Construction project, foresight on Water Resources Development for Water Supply purpose and large scale expansion of systems including treatment plants, distribution reservoirs with pumping stations and distribution mains.

A Brief History of City Water Supply

Taipei Water Works was established in 1909. It utilized the Hsintien Creek as the source to supply water to the city. This system introduced the first slow and filter plant to Taiwan. The designed capacity of the plant was only 20,000 CMD for supplying 120,000 persons.

The system was expanded continuously before and after World War II to meet the increase in demand. However the government's effort toward industrialization and economic development since 1953 suddenly accelerated the concentration of population in the urban area. Minor expansion was found unable to meet the unusual rapid increase in demand any longer, and a large scale long-range development plan was urgently needed by the city authority.

In the first stage of expansion during (1958-1965), a high rate rapid sand filter with appurtenant facilities was added to the system, increasing the output capacity by 240,000 CMD. The service area was expanded to include four townships around the city. Total output capacity was up to 380,000 CMD at that time but the rapid urbanization quickly caught up and further expansion became necessary within a few years.

In the second stage of expansion during (1968-1971), another 240,000 CMD was added to the system's capacity. The third stage of expansion, which was started from 1972 was completed in 1977. The capacity was increased by 480,000 CMD upon its completion.

Existing Water Supply System

The existing water supply system in the Taipei metropolitan community serves an area of some 150 square kilometers, which covers Taipei City and four of its neighboring cities, namely: Sanchung, Chungho, Yungho, and Hsintien. The city of Taipei, provisional capital of the Republic of China, is the political, economic, social and cultural center of the nation.

The following data show the outline of the present status of water supply in the Taipei region:

Service area	about 150 km^2
Total population	3,222,000
Population served	2,977,000
Percentage of population served	92.41
Number of customers	788,000
Output capacity	1,300,000 CMD
Per capita consumption (Including unaccounted-for water	436 L/cap/day
Unaccounted-for water	30%

The water supply in the Taipei region uses the surface flow of Hsintien Creek as the main source. The quality of raw water is soft, corrosive and low in turbidity except for during the flood.

The two plants taking water from the Hsintien Creek currently put out approximately

1,200,000 CMD which contributes nearly 90% of the total supply capacity in the region.

Agriculture and urban development gradually encroaching on the watershed may increase the threat of pollution from insecticide and night soil residues. Besides the surface flow of Hsintien Creek, water from springs, groundwater and surface flow of other minor creeks are also used as local supplemental sources.

Treatment plants are mostly of conventional type using rapid sand filters with flocculation, sedimentation and filtration basins. By feeding alum and providing pre- and post-chlorination, the treatment gives satisfactory water quality.

The pipes are mostly of cast iron type. The largest trunk main is 3,200 mm in diameter. Distribution reservoirs and boosting stations are used to maintain adequate supply to the remote ends of networks and high lands.

Generally speaking, increase in distribution capacity would be required for outlying districts. Distribution storage should also be increased to meet the daily peak demand and provide for short term interruption in supply.

The cost of producing water is about NT$1.57 /$m^3$ (equivalent to US$0.17 per 1,000 gal).

The unit cost of only NT$0.67 m^3 in 1971 has been increased steadily because of higher costs of power, chemicals, and labor.

The Taipei Water Department is managed in accordance with the Water Supply Law, which requires that any water supply undertaking should be self-sustaining. Revenues from supplying water must be sufficient to cover expenses, including operation and maintenance, depreciation, replacement and improvement, debt service, and to provide a reserve for funding expansion projects.

Supply to each customer is metered and the prevailing average water rate is NT$5.60/$m^3$ (equivalent to US$0.56/1000 gal). For conservation of water, charges are cumulative, when a customer uses more water, the unit costs are higher. Basic rates and basic quantities of consumption are set according to the service pipe diameter, rates for excess consumption per customer per month vary from NT$5.60/$m^3$ for excess use of 1-20 m^3 to NT$7.00/$m^3$ for excess use over 1,000 m^3.

The Characteristics and the Problems of the Existing System

At present, the principal source of raw water is the Hsintien Creek. Raw water was taken directly from the intake without ponding storage to regulate and augment the capacity of the flow. Since the dry-period discharge of the Hsintien creek cannot meet the water demand we badly need storage to regulate and augment the discharge by building ponding reservoir.

The Chihtan Dam in Hsintien, however, can only hold as much as 4.2 million metric tons of water, making its regulating function a bit limited. In other words, if water level is low in the Hsintien Creek, the dam can only supply water for a short period.

There was a severe water shortage in the last summer year and we do not have large reservoir to store water in the wet season. As a result, the Water Works had to implement water rationing intermittently during the dry season.

The Feitsui Reservoir to be completed by 1984 will greatly help supply the large water needs in the summer. Before the reservoir is in operation, the water supply in Greater Taipei area has to rely on Chingtan Weir, Chihtan Dam and upstreams of Hsintien.

Last summer, the number of residents supplied with water totaled 2.89 million, with the highest daily water consumption amounting to 1.24 million metric tons. This summer, the highest daily water consumption hit 1.3 million metric tons.

The condition of the plant in general is good mainly because we have many years of experience. Overflow weir loading of the sedimentation basin is 312 CMD/m and filter rate is some 300 – 400 m/day. The above rates are pretty high in comparison with those in other countries. The quality of the finished water is excellent and meets Taipei municipal drinking water standards, which is almost the same as the U.S. drinking water standards. Nevertheless, the quality of tap water is occasionally affected by temporary contamination due to cutoff of water during the connection of pipes, improper disinfection of tanks for indirect use of water, higher iron content of overaged pipes and cross connection. Therefore, measures for prevention of temporary contamination is needed to control water quality.

The entire service area of Taipei is divided into seven zones, and only three zones have their own service reservoir for water regulation, the other four zones are going to construct their own service reservoir to regulate the water demand and maintain a reasonable water pressure in the area. The current total storage capacity of the service reservoirs is 120,000 m^3, which can only sustain two and a half hours of consumption, consequently, it is necessary to increase the storage capacity in the distribution system.

The total length of the transmission mains with diameter above 500 mm is 183.5 km, and the distribution mains is 1735.6 km long in total. These figures are much less than those required to maintain good pressure and distribution, therefore, it is required to increase transmission and distribution main to augment the supply capacity.

The water pressure in the system ranges from 0.2 kg/cm^2 to 3 kg/cm^2, which is too bad. A minimum pressure of 1.5 kg/cm^2 or 2 kg/cm^2 should be maintained in the distribution system to ensure that the household use and fire protection have an adequate pressure. Also, it needs uniform pressure in the distribution system to minimize water loss.

The current unaccounted-for water is 30% of total output. A detailed investigation and prompt action are needed. The factors of unaccounted-for water are inaccurate meters, leakage, public use (such as fire protection, street wash, sprinkling of trees and flowers) and unauthorized use of water. High levels of unaccounted-for water represents a large amount of waste and has the potential for additional revenue. It is evident that the replacement and rehabilitation of over-aged pipes, improvement of water meters, and rigorous control of public and illegal use of water are urgently needed to minimize the unaccounted-for water.

How to expand water supply facilities to supply adequate water remains the major problems for the Taipei Water Dept. Expansion has always fallen behind demands, causing more or less constant water shortage. Good engineering work generally requires adequate time and take advantage of advanced technology. Being pressed to install a new facility in haste or taking the easiest way to meet an urgent demand usually results in a simple conventional design or a mere duplication of existing facilities. In the long run such a system may become rather expensive and inefficient to operate.

Prospects for the Future

The population of the Taipei region is expected to increase continuously until the year 2011, at that time saturation is expected. The estimated population at that time would be about 5.6 million, which is almost double of the present level. Per capita water consumption has increased steadily in the past and is expected to increase continuously in the near future. Because of water shortage in the past per capita water use was difficult to analyze accurately. However, recent data show that per capita water use is about 240 L/day (excluding unaccounted-for water); the average annual increase was about 8 L/person/day in the past several years. In addition to the domestic water requirements, industrial and other requirements are also expected to increase steadily so that total water needs are estimated at 3.6 million m^3/day around the year 2011. It is clear that immense capital investment and engineering efforts will be needed to expand water supply facilities to serve a population of that size. Taipei Water Dept. as the agency in charge is responsible for a long-range development plan as well as effective implementation of expansion projects.

Since the natural flow of the river in the dry season is inadequate to meet growing demands, water source development is a major factor in future expansion.

There is an extensive water bearing zone under the Taipei Basin and groundwater has been used as a supplemental source. In recent years excessive withdrawals of groundwater have caused a substantial subsidence of land, which has limited the continuing role of groundwater in the area's supply.

Comparison of potential alternatives has led to the conclusion that constructing a storage reservoir for the regulation of stream flow is the most suitable method to meet future demand.

Feitsui Reservoir Construction Project

Construction of the proposed Feitsui Reservoir is aimed at providing the Taipei area with a stable source of water for domestic and industrial use. It is a water source development sub-project of the Taipei Regional Water Supply Fourth Stage Development Project. The site of the dam to be constructed for creation of the Feitsui Reservoir is located downstream of the Peishih Creek, which is a tributary of the Hsintien Creek, and is about 30 kilometers away from the Taipei City.

The proposed Feitsui Reservoir will have a maximum normal water level of 170 meters and a total storage capacity of 406,000,000 cubic meters and will adequately meet the water demand for various purposes of use till the target year of 2030. After thorough analysis and careful comparison, it was determined that the type of dam to be constructed at the Feitsui damsite will be a concrete arch dam of double curvature and variable thickness, which has the merits of high safety and strong earthquake-resistance. The crest of the dam will be 500 meters long and the dam will be 120 meters high.

The purpose of the Feitsui Reservoir is mainly for the supply of water. However, for the fullest utilization of the available water resources, a power plant with a capacity of 70,000 kw will also be installed.

Owing to the geographical closeness of the Feitsui Reservoir to Taipei City, first priority was given to insure safety of the dam to be constructed. For that purpose, in addition to assigning the responsibility of study to those experienced engineers who are previously engaged in the design and construction of other high dams in Taiwan such as the Shihmen Dam, the Tachien Dam and the Tsengwen Dam, a number of renowned specialists and academic institutions were also invited to provide the necessary assistance. Such institutions include the Academia Sinica, the National Taiwan University, and the Geological Survey of Taiwan. Furthermore, specialists and consultants of international fame in hydrology, dam engineering, geology, structural dynamics and foundation engineering were invited to join the consulting board to oversee the overall operation of design and construction of the dam and reservoir.

All factors which could possibly cause the failure of the dam, such as destruction by earthquake, sliding of the foundation, overtopping by flood, and even the demolition of the dam by bombs should be carefully analyzed and studied. While such other factors as impounding of the reservoir by stages and the climatic conditions prevailing at the damsite do not have any direct effect on the safety of the dam, these factors together with the estimated construction cost are also included as factors for determination of the selection of the optimum type of dam to be built.

Results of careful studies made of the various factors mentioned above show that, whether from the standpoint of safety or economy, the arch dam is the most favorable followed by the gravity dam, the hollow gravity dam, and the rockfill dam scheme.

After reviewing the stress distribution of the arch dam, and the topographic condition at the Feitsui damsite, it is found that in order to achieve a more even stress distribution in the dam body so as to attain the highest safety and economization, a three-centered arch layout should be adopted.

The structural height of the dam is 122.5 m, the crest length is 510 meters. The thickness of crown cantilever is 7 meters at top and 25 meters at base. The total volume of dam concrete is 710,500 m^3.

We all know that the safety factors of an arch dam are rather high if the foundation of the arch dam is also properly designed. The basic design of the dam foundation comprises stability analysis of the foundation, treatment of bedding seams, and other foundation treatment.

In the stability analysis of the dam foundation, not only the stability of the various potential sliding wedges within the abutment of the dam has been checked, but also the local stability of the various bedding seams in the loaded zones of the dam foundation has been computed.

In order to understand the ultimate factor of the wedge, both shearing friction analysis and sliding friction analysis were conducted without taking into account the effect of bedding seam treatment. The results show that the shearing friction factors of safety of various wedges are much higher than the required value; the sliding factors of safety also meet the design requirements.

Because the continuous bedding seams form the critical weak planes in the abutments, for the purpose of improving the deformation pattern and increasing the stability of the dam foundation, it has been resolved to carry out bedding seam treatment in the loaded zone of the dam foundation.

The bedding seams will be washed by superhigh pressure water jet and backfilled with the non-shrinking mortar, of which the effectiveness have been verified by carrying out material test. The results of the in-situ testing show that the bedding seam treatment is promising.

The local factors of safety of the treated portion of each major bedding seam as well as the average factor of the entire seam were calculated. The results show that no shear destruction of the bedding seam could occur.

The third part of foundation design involves consolidation grouting, curtain grouting, and a drainage system.

In addition to the conventional foundation consolidation grouting, an internal consolidation grouting system to seal off any crack or local open joint in the loaded zone was also added.

Since the strike of the bedding seams in the Feitsui damsite is parallel to the river channel and the left abutment is also a dip slope, a proper design of foundation drainage system is extremely important. In addition to the normal drainage curtain installed downstream of the grouting curtain along the dam foundation, drainage system are also provided in abutments downstream of the dam.

From the above description, we believe that the foundation after treatment, will have the same strength as the dam proper. The integral system of the dam and foundation should be able to undertake the prescribed external forces, including the maximum credible earthquake estimated from a thorough and realistic assessment of the seismicity of the Feitsui dam site.

The water releasing facilities comprise an 8-bay crest spillway with a discharge capacity of 7,670 cms, and 3 sluiceways with a total discharge capacity of 700 cms. The operation of the 8-bay crest along will be able to handle the 5000-year frequency flood, while the joint operation of this spillway and the 3 sluiceways can handle the 7000-year frequency flood. In addition there is also provided an emergency tunnel spillway with a discharge capacity of 1,500 cms. The overall discharge capacity of these water releasing facilities become 9,870 cms, which is considered sufficient to handle the PMF (maximum probable flood) flood. The results of hydraulic model tests show that the water releasing facilities were functioning satisfactorily.

To the immediate downstream portion of the dam, the auxiliary dam will be utilized to form a plunge pool for dissipation of water energy in the discharge of flood so as to prevent scouring of the riverbed downstream of the dam.

The storage capacity of the Feitsui Reservoir, with the normal maximum reservoir water level set at the elevation of 170 m, is 406 million cu.m. With the minimum pool at the elevation of 110 m, the maximum draw down is 60 m. The effective storage of the reservoir will be 359 million cu.m. upon completion of the reservoir and 327 million cu.m. after 50 years of silting.

The reservoir can insure a yield of 40 cms (equivalent to 3,456,000 cmd at the Chingtan Weir), enough to satisfy the demand in the target year of 2030 envisaged in the feasibility study.

The purpose for the Feitsui Reservoir is mainly for the supply of water, however, for the full utilization of the available water sources, a power plant with an installed capacity of 70,000 KW will be installed slightly downstream from the right abutment of the auxiliary dam. As the plant will be operated for peak generation, the pondage formed by the existing Chihtan Dam will be used as an afterbay for regulating water supply releases.

Flood control is not considered a function of the Feitsui Reservoir. However, it is taken into consideration when establishing the reservoir operation rule curves. Results of flood routing computations show that the reservoir has the effect of reducing the flood peaks at the damsite by 6% in case of the maximum probable flood and 29% in case of the maximum recorded flood. Also it is found that the flood conditions in the low-lying areas in the Raipei region will in no way become worse as a result of constructing the reservoir.

After construction of the Feitsui Reservoir, not only the normal streamflow will not be affected but also the gratifiable effect of regulating the streamflow will be created. Moreover, as the requirement of public water supply increases gradually on a year-by-year basis, and because the reservoir will operate before the target year of 2030 according to the full capacity developed, the surplus of raw water can be used to increase the streamflow downstream of Chingtan Weir during the dry season so as to help improve the degree of water pollution in the river channel.

The proposed Feitsui Reservoir Project will take five years to complete. It is necessary, however, in the first-stage of construction to fill the reservoir to the elevation of 90 m by the end of 1981 to meet the additional raw water requirement of 500,000 CMD Chihtan Treatment Plant.

As a matter of fact, the first-stage of dam construction will not be completed until 1983, a delay of two years, and the overall construction of the Feitsui Reservoir is expected to complete in 1986.

Estimates of the total construction cost of this water source development project (excluding interest payments during the period for the execution of the project) will be NT$13,156,000,000 or the equivalent of US$346,210,000. It was approved by the Executive Yuan that the reservoir will be constructed with the Government's financial support as was the case of the Shihmen and Tsengwen Reservoirs.

Execution of the Feitsui Dam project is expected to be completed within five years. However, filling of the reservoir will be made in two stages with the first stage of filling to take place by the end of 1981 to the elevation of 90 meters. This is designed to coordinate with the plan for the expansion of the first Chihtan Water Treatment Plant so as to increase 500,000 tons of raw water each day.

The Fourth Stage Water Treatment Facilities

The proposed intake of the New Plant is located at the right bank of Chihtan dam, (an existing reservoir with a storage capacity of 4,200,000 m^3) and the capacity of the intake is 2,700,000 m^3/day. The waterway between the intake and the treatment plant will be a tunnel, 1733 m long and 4 m in diameter, the capacity of the tunnel is the same as the intake capacity, i.e., 2,700,000 m^3/day.

The project is divided into four stages and the completion of the first stage will increase the water supply by 500,000 m^3 daily. The second stage of the project will be carried out from 1985 to 1991, adding another 1,000,000 m^3/day. The third stage of the project will be completed in 1998, adding 500,000 m^3/day. The fourth stage of the project will be completed in 2003 adding another 700,000 m^3 daily. The finished Water Storage Reservoirs will have a designed capacity of 75,000 m^3.

The functions of the new treatment plants include chemical coagulation, flocculation, sedimentation, rapid filtration and disinfection, however, it is desirable that new technology with high efficiency, low cost, easy operation and maintenance be considered in designing the plants.

Distribution Facilities

It is proposed to construct 4,640 m rock tunnel (diameter 3.4-3.2 m) and 21,500 conduit (diameter 3.4-1.5 m) to connect the outlet of the treatment plant and the distribution reservoirs. It is also underway to construct 129,200 m (o 300-600 mm) and 35,130 m (o 700-1500 mm) distribution mains to augment the distribution capacity to meet future demand, and by now 38;900 m (o 100-1200 m) has already been completed.

The proposed future distribution reservoirs and boosting pump stations will increase the total capacity by some 333,000 tons. Together with the exitsing storage capacity of 120,000 tons, the total storage capacit} of the distribution system will become 453,000 tons.

For the improvement of distribution, Hsintien Distribution Reservoir (4000 m^3) and its pumping station (8000 m^3/day with maximum pump size), and Neihu Distribution Reservoir (25,000 m^3) and its pumping station (40,000 m^3/day with maximum pump size) have already been in use.

The construction cost of the treatment facilities and the distribution facilities is approximately NT$11,500,000,000 or the equivalent of US$302, 000,000.

Conclusion

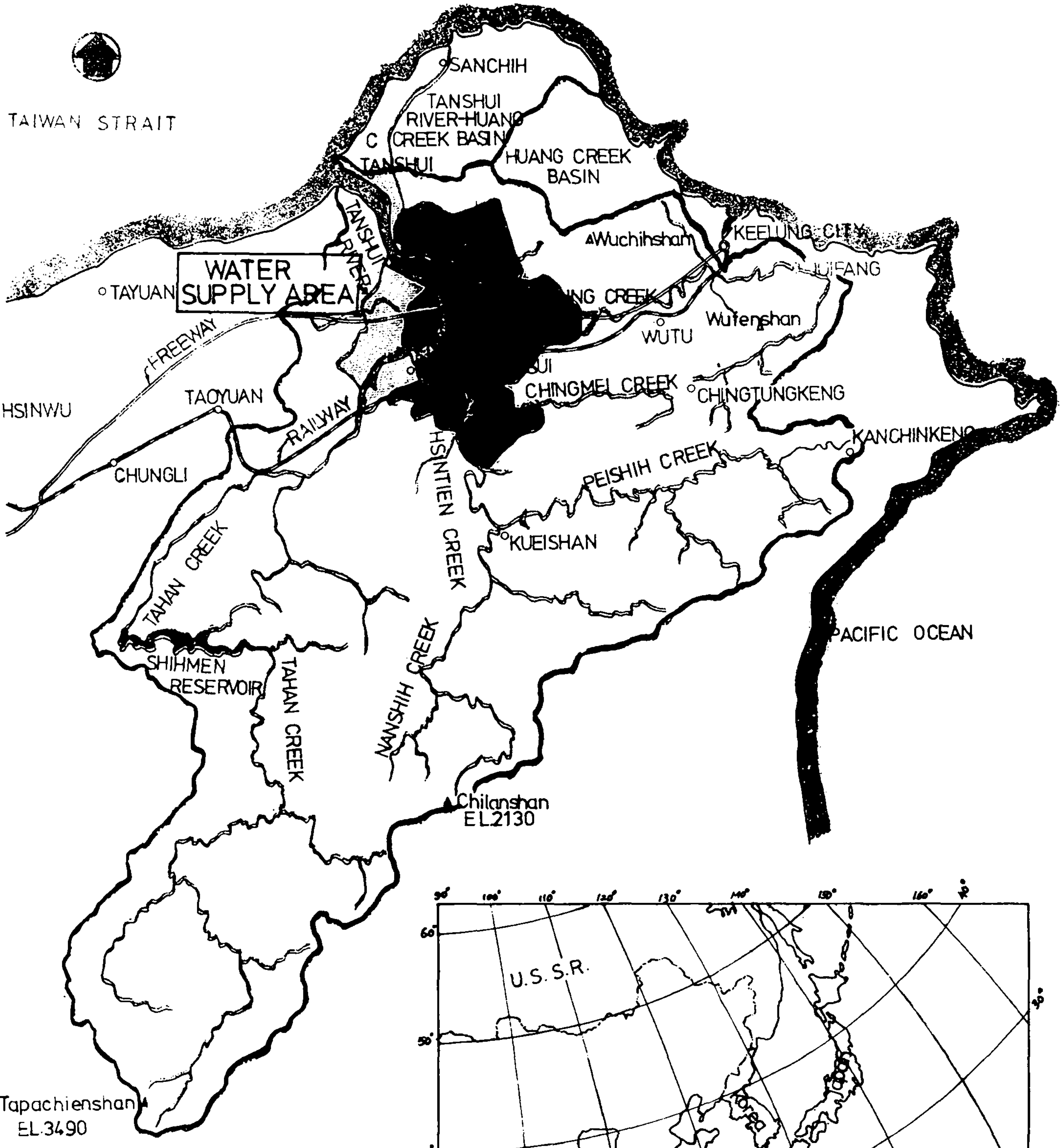
Increase in public water supply demands in Taipei region for the next several decades can be met by building reservoirs on Hsintien Creek. The outlook for water supply development is bright. It is essential that waterworks personnel maintains reliable water source to meet increasing demand, and reliable treatment and distribution facilities to provide uniform distribution and ensure adequate water supply for household, industrial and fire protection use.

An adequate surface water source is also required to replace the present groundwater use to minimize the problem of land subsidence in Taipei area due to overdraft of groundwater in recent years.

It is the responsibility of the water supply authority to employ qualified, experienced professional persons to carry out increasing services. To keep abreast of the public demands and advances in technology requires that the staff be provided with the opportunity of attending special training courses at suitable intervals so that they are able to carry out their duties more efficiently and effectively.

It is evident that the water supply authority should provide adequate, safe water of good quality, reasonable water rate and good services. To fulfill these requirements, it is necessary to make every effort to carry out satisfactory operation and maintenance, intensive continual staged system expansion and betterment of existing facilities. Because of the rapid industrialization and urbanization, and the corresponding increase in population, the requirement for public water supply in Taipei area has been rising rapidly. The inexpensive water sources still permit development, and reallocation and utilization of surplus water sources is urgently needed to minimize the cost of future development.

With the tremendous amount of work to be carried out, particularly in the field of engineering, water supply personnel should be practical and effective to improve every aspect of water supply task. It is a matter of importance that the water authority does its best to increase available safe water, to save water, to decrease the loss and to minimize the unaccounted-for water and to provide the best services.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JUIFANG
WATER SUPPLY AREA
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FREEWAY
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CHINGMEI CREEK
CHINGTUNGKENG
HSINWU
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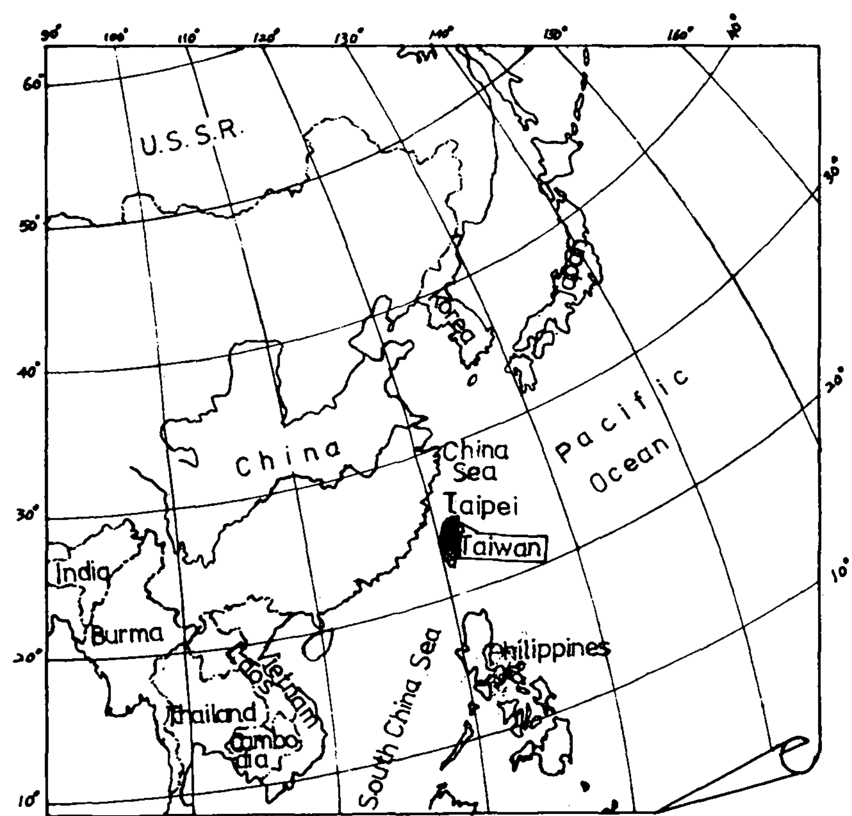
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A MASTER SCHEME FOR SEOUL CITY WATER SUPPLY

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I. Water Supply Plan

1. *Analysis of Present Water Supply System*

A. General

The first water treatment plant of the city of Seoul was built at Tugdo in 1903. At that time Tugdo plant employed slow sand filtration and had a capacity of 12,500 tons per day, which could provide 100 liters of treated water everyday to catch of the 125,000 citizens of the city. Since then, owing to the population increase, city expansion, industrialization, and the advancement of living standards, water demand has been increased rapidly.

At the end of 1979, 3,070,000 tons of water were produced daily from eight major water treatment plants, and 92.4% of population was served with treated water. This resulted in 424 liters of water supply per capita per day. However, 600,000 people or 7.6% of citizens still were yet to be served. Since some water supply facilities have become old, it is necessary to upgrade and replace existing water supply system.

Large amounts of domestic and various industrial wastewater constantly flow into the Han River, which is the sole source of water supply for the city of Seoul. As a result, the river becomes polluted rapidly, especially at the downstream of the Chunggechun, a major tributary of the Han River. Recently, increasing levels of heavy metals discharged in the Han River also create serious public health problems.

B. Existing Facilities

(1) Water treatment plant

All water treatment plants except Bulgwangdong plant depend on the Han River for their water source. Contribution of the Bulgwangdong water treatment plant is only minor and it uses groundwater. Details of treatment capacity and facilities of each plant are shown in Table 1. Total treatment capacity of these comes to 3,070,000 tons per day.

Table 1
SUMMARY OF MAJOR TREATMENT FACILITIES OF EACH WATER TREATMENT PLANT

Treatment plant	Capacity (ton/day)	Quantity			
		Sedimentation basins	Filters	Intake pumps	Transmission pumps
Gueui	830,000	25	62	20	26
Tugdo	500,000	20	54	15	28
NorYangjin	296,000	12	47	11	20
Bogwangdong	300,000	12	20	15	16
Yeongdeungpo	240,000	6	17	7	10
Sunyu	400,000	4	16	6	13
Paldang	400,000	2	16	–	–
Auxiliary	4,000	–	1	2	3
Kimpo	100,000	4	30	3	4
Total	3,070,000				

Table 2
WATER SUPPLY STATISTICS

Year	Population (A)	Number of households (B)	Population served (C)	Households served (D)	Daily capacity (x10, 000 tons)	Water supply rate (%)		Water supply per capita per day E/C ( )
						C/AX100	D/Bx100	
1970	5,536,377	1,097,432	4,737,573	849,819	111	85.6	77.4	234
1971	5,850,925	1,151,078	5,030,000	895,263	128	81.0	77.8	254
1972	6,076,143	1,182,655	5,290,734	976,564	137	87.1	82.6	259
1973	6,289,556	1,215,538	5,530,630	1,015,275	147	87.9	83.5	266
1974	6,541,500	1,273,678	5,835,018	1,129,055	177	89.2	88.7	303
1975	6,887,470	1,410,748	6,140,000	1,168,981	187	89.1	82.9	305
1976	7,254,958	1,461,009	6,520,466	1,315,795	217	89.9	90.1	333
1977	7,526,000	1,529,000	6,848,600		217	91		317
1978	7,823,195	1,609,121	7,150,063	1,471,206	241	91.7	91.4	335
1979	8,114,012		7,497,000		307	92.4		424

As indicated in Table 2, total treatment capacity was 1,110,000 tons per day. But it has been increased to 3,070,000 tons per day in 1979 owing to the expansion of old plants and construction of two plants. It is also shown that water supply rate (% of total population served) and water supply per capita per day were continuously increased.

(2) Distribution and servicc pipes

At the end of 1979, total length of water supply pipes for transmission and distribution was 2,757,698 m, while that of service pipes was 9,658,491 m. However, 7.1% of the transmission and distribution lines of 197 km are older than 35 years, and 28 km of the transmission and distribution pipes become obsolete due to wear and tear every year. Also 3.1% of the service lines or 300 km are older than 15 years, and 130 km of service pipes become obsolete every year.

Water leakage was 40.9% in 1973, and it dropped to 37.5% in 1977. In order to prevent leakage, it is necessary to replace old pipes. Replacement of old pipes also helps prevent contamination and reduce power costs. Table 3 shows inventory of transmission, distribution, and service pipes for water supply.

(3) Service reservoir

Although water treatment capacity is fixed, water demand fluctuates hourly. Therefore storage basin is necessary to compensate for hourly peak demand. Seoul now has 83 service reservoirs with total capacity of 159,623 tons. However, this capacity is merely for 1.5 hours of average consumption, and it should be increased to 1,030,000 tons or 8 hours of supply. Table 4 shows major service reservoirs and their capacity.

(4) Booster pumping station

Because of local and topographical conditions in Seoul, many booster pumping stations are necessary in the distribution system. There are 101 booster pumping stations at many points of the city. They are specifically designed for water supply for low water pressure region and for regions of high elevation.

Table 3
PIPELINES FOR TRANSMISSION, DISTRIBUTION, AND SERVICE

	Total length (a)	Total obsolete (b)	rate (b) / (a)	Annual increase of (b)	Remarks on (b)
Transmission and distribution	2,757 Km	197 Km	7.1%	28 Km	older than 35 years
Service	9,658 Km	300 Km	3.1%	130 Km	older than 15 years
Total	12,415 Km	497 Km	4.0%	158 Km	

Table 4
CAPACITY OF SERVICE RESERVOIRS

Service reservoir	Capacity (ton)
Noryangjin	16,920
Daehyunsan	58,500
Hongundong	12,500
Samchongdong	5,000
Manridong	6,000
Bundong	10,000
Chungdamdong	10,000
Auxiliary (Public)	38,104
Auxiliary (Private)	2,599
Total	159,623

1. *Water Supply Plan*

A. General Direction

Owing to industrial growth and population increase, the Han River has been polluted by large quantities of domestic and industrial wastewater. Therefore, raw water for all treatment plants should be obtained from Paldang reservoir in near future. Paldang reservoir is located far upstream of the Han River and the water maintains good quality.

Besides, following items must be considered as a general direction for the water supply plan.

1. From the viewpoint of energy saving, gravity flow system should be fully utilized instead of pumping.
2. Considering national security and defense, all structures and equipments for intake, treatment, and distribution should be built under the ground level.
3. In order to maintain water quality of the Han River, sewage and industrial wastewater outfalls should not be located at upstream of the intake for water supply.
4. For buildings and institutions that use large amounts of water, spent water should be reused for non-potable water supply. Individual wastewater treatment facilities may be required for those who use large quantities of water.
5. Automatic control system should be adopted for water treatment and distribution system.
6. Against degradation of water quality in the future, a unique treatment method which is suitable for the city of Seoul should be devised.
7. In order to minimize leakage, water supply pipes should be well maintained and cleaned.
8. When there is a significant change in water supply or demand, adjustment of the existing distribution system should be carried out in advance.

B. Water demand estimate

In order to estimate future water demand, it is essential to determine population, water supply rate, and water supply per capita per day. Among them, future population is estimated from predetermined population index described in the population plan. Water supply rate and water supply per capita per day depend upon many factors such as type of city, climate, life style, living standard, and water quality; therefore, it is very difficult to predict them. Generally, there are several ways to estimate water supply rate and water supply per capita per day. They can be estimated from previous water supply data of the city. A functional relationship between water supply and economic growth may be established and utilized. They can also be estimated from other city's experiences. In this plan, a method which compounds above methods is adopted.

(1) Water supply per capita per day.

Because of limited water resources and economic reasons, maximum water supply is set at

600 lpcd (liters per capita per day), and if water demand exceeds 600 lpcd, reuse of spent water is recommended. Based on annual increase of 10 – 15 lpcd, it will be 520 lpcd in 1991 and 600 lpcd in 2001.

(2) Water supply rate

Considering topography and housing distribution of the city, it is very difficult to provide all citizens with city water. Based on previous water supply records and examples of other cities, increase of water supply rate has been set at 0.5% per year until 1991; however, the water supply rate becomes constant after it reaches 98%. With 520 lpcd and 98% of water supply rate, total water demand will become 4,660,000 tons per day in 1991. Details of water demand estimate are shown in Table 5.

C. Water supply plan

Based on estimates described above, a water supply plan has been established as shown in Figure 1. Details of the plan are as follows:

1) Until 1979, city of Seoul takes over Kimpo treatment plant from the city of Inchon and the capacity of Kimpo plant will be increased from 100,000 to 200,000 tons per day.
2) Paldang water treatment plant will be built by 1981. Capacity of the Paldang plant will be 600,000 tons per day, and total capacity will be 3,770,000 tons per day.

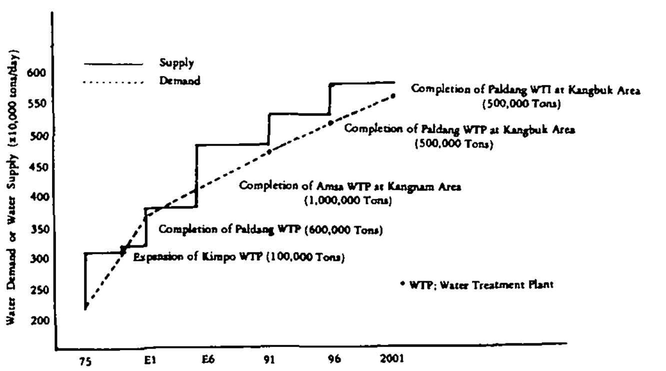

FIG. 1. WATER SUPPLY PLAN

3) It is expected that water demand will exceed water supply by 890,000 tons per day by 1991. A new treatment plant capable of producing 1,000,000 tons per day will be built at Amsa area (south side of the Han River). Raw water for the treatment plant will be supplied from Amsa intake. After completion of this treatment plant, the total capacity will be 4,770,000 tons per day.
4) After 1991, a new water treatment facility capable of producing 1,000,000 tons per day will be built at Kangbuk area (north side of the Han River). Paldang reservoir will supply raw water. Total capacity after completion of the treatment plant will be 5,770,000 tons per day.

Since river water near the intakes of existing water treatment plants at downstream of the Han River has been polluted, the Ministry of Construction has proposed a metropolitan water supply plan. According to the plan, supply of river water to the existing water treatment plants will be replaced with reservoir water from Paldang. Noryangjin, Yeongdeungpo, and Sunyu water treatment plant receives 217,000, 250,000, and 200,000 tons per day, respectively. The plan also includes 1,000,000 tons of supply to the new plant at Paldang, 300,000 tons to Inchon, Suwon, Anyang, and Banwol, and 368,000 tons to the new plant. Therefore, 2,000,000 tons of additional supply to Seoul should be included in the plan. And the construction work of the additional intake facilities at Paldang reservoir should be carried out simultaneously. A simplified distribution system plan is included in Figure 2.

Because Seoul's water supply heavily relies on the Han River, it is desirable to have an additional water supply source against water shortage in the future. The Imjin River may be considered as an alternative source of future water supply. The river is located as far as the Paldang reservoir from Seoul. In this case, the intake structure and its facilities should be located under the ground.

Because of unfavorable surrounding environment, degradation of water quality may be unavoidable in the future. And for the present, it is desirable to improve quality of the supplied water. Therefore, it should be studied to adopt additional treatment methods such as ozonization and activated carbon absorption.

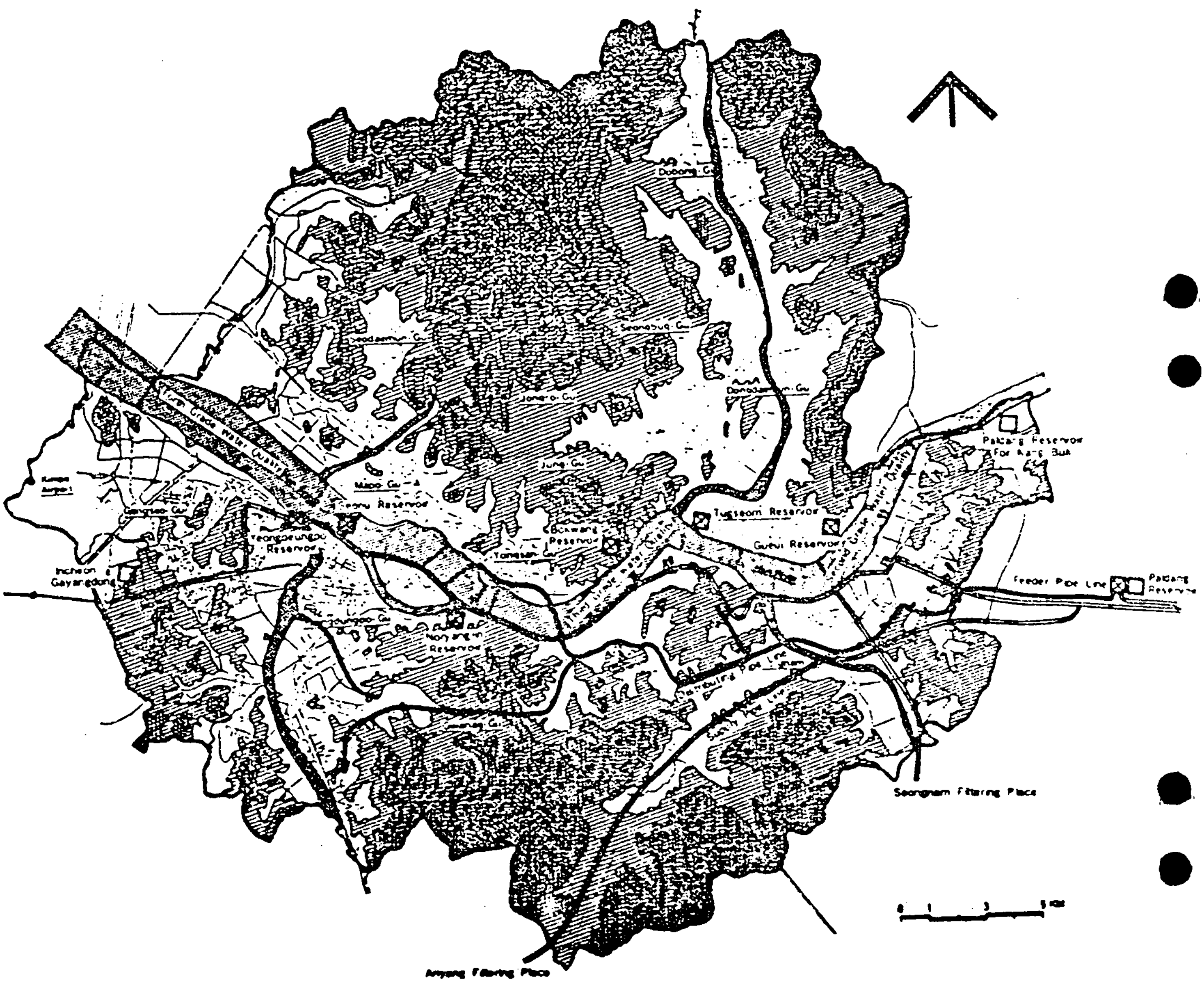

FIG. 2 PLANNED WATER SUPPLY NETWORK

INTERNATIONAL DRINKING WATER SUPPLY AND SANITATION DECADE

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INTRODUCTION

Over 13 million children die in the developing countries every year. It is tragic that most of these deaths could be prevented with only modest efforts because one key factor is the lack of safe drinking water, combined with the inadequate disposal of human excreta. Nearly one-third of these deaths are due to diarrhoeal diseases which can be related mainly to unsafe drinking water.

In addition to the deaths, there is much intestinal illnesses, skin ailment, eye infections, helmintic infestations and other diseases that are either water related or due to poor environmental sanitation and personal hygiene. In millions of households in the developing world, women and children spend countless hours every day to draw and fetch water from sources away from their homes. This is an unbelievable waste of human time that could be spent in constructive household activities, including rest and care of the individual in the highly stressed environments found commonly in the developing world.

On a global basis, approximately three out of five persons on the developing countries do not have access to safe drinking water; only about one in four has any kind of sanitary facility, be it only a pit latrine. The urban areas are better served with 75% of the population having some form of water supply through house connection or outdoor standpipes, and 53% having adequate sanitation. However, in the rural areas only 29% have access to safe drinking water, while only 13% suitable sanitation facilities.

The work facing those who are working in water supplies and sanitation programmes for all is formidable. The global programme means providing 3000 million people with new or improved services, at a cost of between US$300 to 600 billion (1978 rates), depending on the level of technology chosen. On an annual investment basis capital needs will be about US$30 to 60 billion over the next 10 years.

THE INTERNATIONAL DECADE (1981-1990)

The World Health Organization has long recognized that safe drinking water and adequate sanitation are fundamental prerequisites for good health and well-being. The United Nations Conference on Human Settlements (Habitat – 1976) initiated the current thrust toward the 1990 target date but it was the United Nations Water Conference (1977), which expressed the global concern and specified a plan of action. In 1978, the United Nations General Assembly declared that the decade of the 1980s would be the International Drinking Water Supply and Sanitation Decade, thus providing the basis for the formal initiation of the global programme. The United Nations General Assembly launched the Decade officially on 10 November 1980.

The United Nations Water Conference of 1977 laid down the essential details of the Decade's implementing structure. At international level, the United Nations Economic and Social Council plays an overview role. At the country levels, this is followed by the respective Resident Representative of the United Nations Development Programme, who acts as the focal point for the external agencies and the United Nations system, and for the technical support received from WHO, UNICEF, ILO, FAO and other agencies.

The primary responsibility for Decade activities rests with the respective country. Decade targets will be individually interpreted within a national context, and the detailing of strategies, plans and programmes for each country will be a national activity. National action or coordinating groups will be formed to promote and coordinate intersectoral governmental activities.

At national level, the elements elmeents identified as components of a new approach to the Decade include:

- recognition of the complementarity of sanitation and water supply development;

- strategies that stress the covering of the underserved populations, both rural and urban;
- generation of replicable, self-reliant and self-sustaining programmes;
- use of socially relevant appropriate technology that is affordable;
- community participation at all stages of project development, implementation and operation;
- linkage of water supply and sanitation with other health improvement;
- close relation of water supply and sanitation projects and programmes with other sectors, as a basis of community development.

The Decade approach as described is closely linked to the principles of primary health care. The attainment of the Decade goals and the success of primary health care have many common denominators. The Decade could be a spearhead of primary health care, linked to the broader goals of community and rural development activities of which primary health care is an important component. In this respect, the Decade is an essential link in the attainment of the goal of health for all by the year 2000.

SECTOR CONSTRAINTS

The difficulties within the water supply and sanitation sectors are well documented. The low level of service coverage in most developing countries is a poignant reminder that, after more than three decades of efforts, sector development has been inadequate, even to keep abreast of most population growth. At the country level, these shortcomings in coverage have been magnified by the following factors:

(1) The sector always seems to be short of trained manpower.

(2) Systems are not maintained, so that actual service is usually lower than recorded coverage.

(3) Institutions and sector agencies can cope with limited urban programmes but immediately become overstretched if programmes have to be extended.

(4) The sector is starved of finance, unable to raise sufficient funds, either internationally or through government subsidies, and has more difficulty funding local recurrent costs than development expenditures.

(5) There is little relationship between water supply development, sanitation and public hygiene.

At the operational level, national strategies and programmes are constrained by policies, institutional and technical inadequacies, among which the following are salient factors:

(1) undue priority given to urban and the most vocal groups;

(2) over-reliance on central management for community water supply and sanitation systems;

(3) insufficient use of lower level techniques, artisans and community level workers; and

(4) inappropriate technology which is incompatible on a socio-economic basis.

For more than three decades, international cooperation in the sector has demonstrated the inadequacy of the response to national needs. Programmes have become reactive in posture and have been directed primarily to engineering projects to increase service coverage without consideration for essential support elements. The weaknesses of international support are exemplified by the following:

(1) Technical cooperation in the past have been passive in response to specific government requests which are not linked to long-term sector goals.

(2) There has been concentration on large individual projects which have a minimal multiplier impact.

(3) There has been a high technology base, which is relevant to the urban environment.

(4) An agreed mechanism for technical and other support between United Nations agencies and with developmental agencies has been lacking.

THE NEW APPROACH

If the same standards of service and methods of implementation as have been used in the recent past are used during the Decade, the target may never be reached. Lower unit costs and standards of service must be accepted and local community and external resources must be greatly increased. There are no reliable statistical estimates of how many public and private water and sanitation facilities have fallen into disuse or disrepair; it must be assumed that much more needs to be done about their maintenance and upkeep, about water quality, and about the improvement of the technical and financial administration of water and sanitation systems. Finally, much greater attention must be paid to sanitation; in the past the provision of drinking-water was often given overriding priority. Water supply, sanitation, and health education of the general population go together.

The new approach of the Decade recognizes biases and shortcomings in national plans and programmes and in the support provided by the international community. Many of these shortcomings are common to other sectors and stem from unbalanced policies for overall development; some are symptoms of more fundamental problems. A short discussion of these elements follows.

Complementary sanitation and water-supply development

Improvements in community water supply have to be closely coordinated with sanitation, the sanitary disposal of wastes (including excreta) and health education if they are to have a significant impact on health conditions. The United Nations Water Conference in 1977 mentioned sanitation and waste-water disposal in connection with the water targets. The World Food Conference's recommendations on improvements in basic sanitation; and the Twenty-second Session of the UNICEF/WHO Joint Committee on Health Policy, held in January 1979, recommended that governments and international agencies should give a higher priority to sanitation and to complementary measures for water supply and sanitation.

If hygiene and sanitation are below a certain level, improvements in the quality and possibly even the quantity of drinking-water are unlikely to improve health status; but combined water supply and sanitation, together with health education, are formidable weapons in the fight to achieve health for all.

The Decade must therefore raise levels of basic sanitation by well-defined programmes so that the health benefits of water supply development can be fully realized.

Strategies that give precedence to underserved population, both rural and urban

The United Nations Water Conference emphasized that priority should be accorded to the "poor and less privileged." It was recommended that plans and programmes for community water supply and sanitation and socioeconomic plans made during the Decade should give "priority attention to the segments of the population in greater need."

The problem of primary health care is to cater for the "disadvantaged groups throughout the world" which have no access to any permanent forms of health care. These groups probably total four-fifths of the world's population, living mainly in rural areas and urban slums.

It is true that there will also be new demands from middle-income consumers in the major towns, which will feature strongly in the augmentation programmes of developing countries and which will, because of population growth, have a claim to the benefits of the Decade. However, institutions catering for these demands are already relatively strong, and they will find other resources, as they did in the past, to build the extra facilities. The Decade must give explicit priority, and national and international agencies must give assistance, to the poor rural and urban-fringe populations in order to compensate for their underprivileged position.

Each country has its own characteristics, but the underserved populations are mainly found in the rural areas and in the poor fringes of towns and cities.

Where smaller market towns can be developed as growth centres under rural development programmes they will appreciably improve conditions for the rural poor and for the immediate population; the effect is, however, indirect. Where centres of growth actually link scattered rural populations, using water supply and other services as a focal point of attraction also for migrants, the impact is direct.

Acceptance of the idea that provision for these basic needs is a human right carries a number of implications for the Decade. First, developed countries must recognize a responsibility to assist the developing countries in implementing national policies to minimum standards. Secondly, water supply and sanitation are explicitly linked with developments in health, education and housing. Thirdly, the "basic needs" principle does not require any other justification. Fourthly, no matter what current level of development or social structure exists, the principle is of universal application.

Programmes that will serve as a model for self-reliant, self-sustaining action

The significance of the Decade's targets for national water-supply and sanitation institutions and agencies cannot be overstated. Concentration on underserved populations implies, in many cases, a significant reoreintation of strategies and approaches that cannot but affect such structures. Institutions and programmes that have mainly catered for the urban middle class, with limited, slow-moving, rural programmes as mere adjuncts, are clearly not going to be suited to the new objectives.

A number of constraints have combined in the past to inhibit the rapid spread of programmes that can serve as a model for self-reliant and self-sustaining action; such constraints as the following will continue to operate in the future unless deliberate changes are made:

(1) centralization has limited the capacity of the institutions and their staff for local action, especially in areas with high transport costs; there are frequently insufficient permanent district or sub-district staff;

(2) too little responsibility has been given to non-professional staff and the ratio of non-professional to professional staff has been too low;

(3) non-professional manpower has been deprived of information and technical guidance;

(4) technology and design criteria have been set too high;

(5) schemes operated by national agencies have tended to be larger than can be managed by a

single village or community and to ignore poor populations; and the limited availability and mobility of the agencies' highly trained manpower have made it difficult to apply such schemes elsewhere;

(6) funding for recurrent expenditure has frequently not been assured;

(7) agencies have not been geared to supporting broad-based programmes with priority to the lowest levels of activity (where the community auxiliaries are cooperating with government agency staff).

Current strategies to improve water supply and sanitation usually extend coverage district by district (narrow-front strategies); the alternative is a broad national strategy, depending increasingly on community resources, adopting lower standards of service and removing constraints progressively (consistent with the Decade's emphasis on decentralization and community participation), and involving, as necessary: the motivation of communities and the enlistment of their support; the training for local employment of more non-professionals; the development of support and referral systems at all levels to ensure that constraints are removed at the level at which they arise; and appropriate technology.

While village or community involvement and commitment are to be encouraged and taken advantage of, some central or regional government support is almost indispensable; if operation and maintenance by central and regional departments can be reduced to logistic planning, supervision and evaluation, with quarterly or yearly checks on general rural works, then central agencies will be able to cope with the more regular checks and work on the larger, more sophisticated plant and machinery, of which there is correspondingly less.

Community auxiliaires can be motivated and trained to maintain and repair equipment, local contracts for which can be given to village smiths or artisans or to a multipurpose village maintenance unit. Other maintenance checks can be done according to an established schedule by technicians with well-defined district responsibilities and with access to more sophisticated technical support if necessary.

While it would appear essential to decentralize the Decade's activities, flexibility will always be required, and they cannot be decentralized unless there is adequate support and referral. Some if not all of the following responsibilities are usually not decentralized:

- preparation of national plans and budgets;
- provision of mechanisms for the allocation of funds;
- research and development and, in particular, the development of standards and design, construction and operation;
- procurement of imported materials;
- organization of manpower development;
- promotion and organization of education of the public;
- subsequent evaluation of programmes and projects.

Programmes that can serve as a model, by stimulating other interested parties, multiply the benefits of the planning effort. First, their success commands recognition and invites imitation. Secondly, they are an experiment in communication, requiring progressively greater commitment. Thirdly, they are exercises in coordinative management for various sponsors and participants (government officials, professional educators and project staff, community leaders, teachers, parents, etc.). Fourthly, the key quality of such a programme is its ability to remain flexible and to absorb knowledge and experience for the orientation of further programmes. Fifthly, decisions are local, and essential responsibility is close to the programme. In summary, a good programme of this kind is technically more inventive, socially more progressive, and better integrated than is common at present.

Reproduction of self-reliant and self-sustaining programmes depends on choosing the right techniques and on using the right media for the communication of infromation. Communities and junior non-professionals can, with the necessary support, handle many local tasks if the technology is relatively simple, such as the development of shallow wells and the protection of springs for rural water supply schemes. In many cases they may be able to develop reticulated systems if materials are made available. Appropriate means of communication must be used in training senior and junior non-professionals and in motivating them for their work as well as for their contacts with the community. For example, the protection of springs can be described simply in a guide for use by senior non-professionals, and some of the construction, operation and maintenance of spring protection devices can be done by junior non-professionals and community auxiliaries.

The broad strategy assumes that the Decade will first lay the groundwork for programmes which will subsequently be expanded, with gradually rising standards of service. The motivation of communities, the training of non-professionals, the development of local supply depots and production capacity, the preparation of communication and guidance material, and the reorientation of senior staff will all take time. However, once this groundwork has been done, nationwide progress can be very rapid.

Socially relevant systems that people can afford

If the Decade can promote more simple, cheap and safe community water-supply and sanitation schemes which people accept and use, it will make matters much easier. Where schemes are understood and wanted by the community, people are like to find more of the resources necessary to construct and operate them.

If there is no appreciation of what communities want and need, terrible blunders can be made; many stories are told of how people destroyed or neglected water and sanitation facilities that were installed without prior consultation.

Furthermore, technology must be appropriate. The aim is not only to reduce costs; installations should be simple to operate and maintain using the knowledge available in the village or small town concerned. Technology should be chosen that economizes on foreign exchange and encourages local employment, and which allows for continuous improvement with a view to further development. Appropriate technology is not a "second best;" it is a way of keeping pace with development. Water-supply and sanitation technology should fit in with development in other sectors. This is the only way to encourage local development and to ensure that technological change is accepted as part of the social fabric.

Appropriate technology is also more socially relevant when it is sufficiently in advance of traditional technology to increase private and social benefits but not so advanced that it cannot be understood and its tools repaired, maintained and adapted. The common failure to operate and maintain installations is due to earlier neglect of this factor; techniques alien to people's culture of level of development have been imposed on their society and communities. Another approach, using more sophisticated technology with central agency staff, has failed in so many countries that a complete change is necessary.

Association of communities in all stages of projects (planning, construction, financing, operation and maintenance)

The broad approach which is advocated calls for increased support from the lay community. Efforts must therefore be directed towards promoting local initiatives and then responding to them. Community participation is not just an adjunct of central programmes, an additional requirement imposed by central agencies, some new fad or trend; it is vital to the Decade approach.

The emphasis is on mobilizing the community because past programmes failed to increase coverage rapidly or to operate and maintain the facilities. Agencies have been unable to provide local services to the rural and urban poor; isolated programmes, where they have been attempted, have all too often lacked the social relevance which involving the community helps to ensure, utilizing resources within the community to satisfy community needs.

Some communities, especially in arid and semi-arid areas, are very poor and cannot make any substantial contribution to water-supply and sanitation measures; but most rural and urban-fringe communities can, not only directly through free labour or cash payments but also indirectly through such means as hygiene education of the public (creating awareness among household users in order to improve their surroundings), and diagnosis of problems and monitoring of programmes by members of communities themselves.

Activities to promote community participation have been summarized by the UNICEF/WHO Joint Committee on Health Policy as follows:

"(1) Operational research, needed for the preparation for participation. Studies are not only important on a country basis, but also in the initial phase at the community level to test reactions and to understand relevant information that will influence construction and operation of facilities.

(ii) Continuing information services, to inform and promote methods of preventing diseases associated with contaminated water and poor sanitation, and to increase awareness of the cost of improving water and sanitation. People need to be informed about the importance of protection, and about operation and maintenance of facilities and services;

(iii) Involvement of the community in decisions, costs, and actions, including (a) helping to plan, select sites, construct, operate and maintain safe water supplies; providing drainage for the removal of water and wastewater; maintaining pumps, communal water points and their surroundings; (b) improving household surrounds; (c) constructing latrines including the fabrication of water seals and latrine slabs; (d) the practicing of household hygiene for the sanitary storage, protection, and preparation of food; utilizing clean vessels for the storage of water; and removing and sanitary disposal of solid wastes (garbage) in and around the household;

(iv) Determining appropriate institutional organizations at the village level and delegating authority for organizing and supervising community participation, including managing the water supply and sanitation facilities after construction. While there is no single ideal type of organizational structure, the effectiveness of whatever structure is chosen will depend on an appropriate composition of members. The tasks of these community institutions usually include organization of labour, contribution, cash collection, and operation and maintenance of systems;

(v) Redefining as appropriate the roles, resources, and working patterns of official supportive organizations, particularly where governmental services find that within their infrastructure they have neither the personnel nor the facilities to cope with participation on a large scale;

(vi) The creation of a coordinating mechanism that can effectively function at all levels in cases where the responsibility for water supply rests with more than one Ministry, and thus creates fragmentation of efforts, waste of resources, and competitiveness for participatory actions. Since in many countries the responsibility for sanitation, particularly for rural sanitation, is often completely divorced from responsibility for water supply, appropriate coordinating or linking mechanisms are called for."

As small water schemes, basic sanitation and hygiene education are to feature more prominently in the Decade, communities and their representatives can play a greater part. Communities can do much more, especially with the cooperation of permanent agency staff and support services on the spot.

Decentralization of government and of competent agencies is essential to provide the on-the-spot support services to communities. However, it is expensive as it often entails an increase in agency staff which in turn raises recurrent costs. Costs can be kept down if more intermediate-level staff are used. In any case, without the participation of community organizations, the inability to operate with central resources and capacity alone would soon impose the most formidable constraint on attainment of the Decade's targets. Where local government is strong, increasing devolution of responsibilities is consistent with the principle of self-reliance.

Community participation in water supply and sanitation is not a new idea, and it maybe asked what there is in the Decade approach that can make it work. First, the Decade should generate greater political will to make it work. Secondly, all the other elements of the Decade approach must, as a matter of policy and strategy, emphasize community participation.

Coordination of water-supply and sanitation programmes with those in other sectors

The Decade requires links between all sectors involved; first, because the "basic needs" argument will not itself generate enough funds or resources to meet the basic objective of total coverage; secondly, because the local development process and a community's appreciation of its needs do not respect narrow boundaries between different sectors where the problems are closely interrelated.

Rural water supply and sanitation can be found as components in programmes of primary health care, rural development, community development, child health and child care, and water resources development. Collaboration between authorities for agriculture, communications, education, health and public works is usually necessary for the success of such programmes. Urban water supply and sanitation are also closely related to urban land use, housing development, city planning and satellite settlements. Basic urban sanitary services could be successfully included in different kinds of local development programme in order to secure higher priority, more funds and stronger institutional support.

Many of the hopes raised by integrated or intersectoral approaches will prove vain and cause increasing frustration unless the issue of their proper management is squarely faced and resolved in the Decade. The compartmentalization of agencies and tasks, the rigidity of an allocation of responsibilities strictly according to functions, and the lack of involvement of social groups directly concerned with the programming are common obstacles to the implementation of mutual support programmes. There are other problems: decision-makers in charge of "vertical" programmes in certain sectors may not want to see their activities subjected to new types of coordination; intersectoral programmes have many masters so that overall control of budget, staff and materials is difficult; and management of such programmes has not been impressive. The answer to these difficulties may lie in strengthening the role of lower levels of government. The better the knowledge of the situation, the closer the identification with the problem and with the community to be served. The greater motivation which results will usually facilitate intersectoral planning and programmes and the integration of activities at the lower governmental levels.

Poor communities have to increase their incomes if they are to pay for improved services, and the Decade should provide the means for them to do so. Investment in water supply and sanitation has to be looked at in relation to overall development. Water supply and sanitation cannot be made to command more resources simply by being attached to development projects, although urban housing, resettlement and irrigation schemes do command such resources. The point is that the returns are higher if the schemes are links in a development chain. With water supply and sanitation, the social returns are higher if there are health benefits; this is well appreciated. The productivity of those who otherwise have to fetch and carry water over long distances can be increased; this also is well appreciated. Less well appreciated, however, are the ways in which water supply and sanitation have to be further linked with agriculture to increase food production and nutrition, to eradicate or control schistosomiasis and malaria, or to provide compost or algae for cattle feed. Programmes must also be jointly planned with family health, nutrition and health education programmes. Local building materials and equipment are supplied by public or private workshops; the same workshops can produce materials and equipment for other sectors. Community workshops could also repair and maintain equipment for different sectors.

It is not enough simply to appreciate these principles – the Decade must come up with explicit procedures, programmes and means of coordination and planning which provide for funding and support of joint projects. The major weakness of intersectoral programmes is institutional; departments and ministries responsible for traditional sectors resist change. The same problems face primary health care and rural development workers. The solutions that have been found in other endeavours can be used for the Decade.

Association of water supply and sanitation with health improvements

The Decade is to bring about improvements in health, not just the construction of more public and private water and sanitation systems. All concerned must join forces to ensure that water and sanitation give better health; it cannot be assumed to occur automatically.

Resolution WHA30.33 of the Thirtieth World Health Assembly on the United Nations Water Conference urged Member States, *inter alia*, to formulate programmes giving specific attention to the prevention of pollution of water sources and the spread of disease resulting from polluted water. Member States were also urged to ensure that people consume water of good quality by periodic inspections of water sources and treatment and distribution facilities, by improving public education programmes in the hygiene of water and wastes, and by strengthening the role of health agencies in this respect.

The association of water and sanitation with health improvement is such that this element of the Decade approach is to be regarded as a problem not of intersectoral coordination but of coordination within the sector.

Water-related communicable diseases are rare in developed countries; levels of development, the high proportion of house connexions, and water-carried sewerage have combined to eradicate the principal causes. The gradual separation of the responsibility for water and sanitation from those of health agencies was therefore unobjectionable. In many developing countries, however, the division of responsibilities for health and for water and sanitation has proved disastrous.

Those who design programmes have to consider the relation of water supply and sanitation to health in a given environment and ensure that improvements will in fact result, instead of merely monitoring or measuring the health impacts of water and sanitation investments. This is the real point in counting water and sanitation as part of primary health care. Preventive measures cannot be deleated to institutions with no responsibility for health. Investment-oriented institutions cannot be expected to promote water use and sanitation for health reasons. The Decade must clarify the role of health agencies in many countries.

If the ways in which better water and sanitation contribute to a general improvement in health and *vice versa* are insufficiently appreciated, the following negative aspects should be considered:

- polluted water and insanitary disposal of excreta will endanger health;
- lack of personal hygiene may invalidate the benefits of clean water;
- water impoundments and irrigation schemes may increase the risk of malaria, schistosomiasis and, possibly, onchocerciasis;
- improvements in water supply and sanitation will not bring maximum health benefits if other essential components of primary health care – particularly, nutritional improvements, diarrhoeal disease control, maternal and child health and education – are disregarded.

The weight given to health in water-supply and sanitation programmes will partly depend upon the division of responsibilities between water-supply and sanitation and health agencies, but the attitude of the health agency, as the one primarily responsible, will be decisive. Essentially, the challenge is to relate Decade planning to the planning for health for all. National health development plans should contribute to and accommodate national Decade targets.

Conclusion

The International Drinking Supply and Sanitation Decade was launched on 10 November 1980 in a special one-day meeting of the United Nations and developing countries will be required during the Decade (1981-1990) to meet goals for new or improved water supply and sanitation facilities. To meet these goals for greater service coverage, a new approach has been proposed which will complement the traditional engineering methods with a people-intensive approach, involving health education and community participation. This new approach will involve not only a commitment by governments but also people themselves at the community level, who are the main beneficiaries. Each project must begin with the community, involve the community and belong to the community.

There is great hope that the goals of individual countries can be met and for people working in water supply and sanitation, this is the challenge of the Decade.

PROJECT APPRAISAL REQUIREMENTS OF ADB

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INTRODUCTION

1. The Asian Development Bank is an international development finance institution owned by its member countries. Its main role is to promote the economic and social progress of its developing member countries (DMCs) by lending funds and providing technical assistance.

2. The Bank opened for business in December 1966 with its headquarters here in Manila. It has 44 members – 30 from Asia and the South Pacific and 14 from outside the region. Regional membership consists of 27 DMCs and three developed countries. The 14 non-regional members are 12 countries from Western Europe and North America.

3. The Bank makes two kinds of loans – "ordinary" loans to the somewhat better off DMCs and "concessional" loans to its poorer and less developed member countries. The current lending rate on loans from the Bank's ordinary capital resources is 10.1 per cent a year with a maturity period of between 10 and 30 years and a grace period of between 2 and 7 years. Concessional loans carry only a service charge of 1 per cent a year with repayments extending over 40 years including a grace period of 10 years.

4. As of 31 December 1980 the Bank had made 506 laons totalling $8.1 billion for 455 projects. A little more than one-fourth of this amount was provided on concessional terms to poorer and less developed member countries. In 1981 it is expected that 55 projects will be financed with loans amounting to about $1.68 billion.

5. ADB assistance is mainly provided for projects involving agriculture and agro-industry; energy; industry and non-fuel minerals; development banks; transport and communications; water supply; urban development; and education. The percentage of lending each year for specific water supply projects (including sewerage and sanitation) has been relatively consistent at just less than 10 per cent of the Bank's lending. In addition, a large number of urban and rural development projects, including irrigation projects, have potable water supply and sewerage components. As of 31 December 1980, 40 loans had been made totalling $706 million for 36 water supply and sewerage projects in 14 countries. Most of the projects financed (30) have been for water supply while 4 have been for sewerage and 2 have been for projects combining water supply, sewerage and drainage. In 1981 it is expected that four loans for $123.7 million will be provided for the sector.

6. For the first ten years of its operations, the Bank's role in the water supply and sewerage and sanitation sector was confined to expanding water supply and sewerage systems in major urban areas. In the last four years, however, the Bank has become increasingly involved in providing water systems in small urban and rural areas, and it is expected that this trend will continue.

OBJECTIVES OF APPRAISAL BY THE ADB

7. The Bank in its operations is guided by Articles of Agreement contained in an agreement Establishing the Asian Development Bank which came into force on August 1966. Of particular reference to the need and objective of appraisal is paragraph (xi) of Article 14 – Operating Principles which states "The Bank shall take the necessary measures to ensure that the proceeds of any loan made, guaranteed or participated in by the Bank are used only for the purpose for which the loan was granted *and with due attention to consideration of economy and efficiency.*" (underlining supplied). Therefore, in order to achieve this requirement it is necessary, when presenting a loan for approval to the Bank's Board of Directors, that the recommendation for the loan be based on a full, comprehensive appraisal of all relevant data as they pertain to the proposed project.

8. Outlined below are the major steps taken by the Bank when it appraises a project in the water supply and sewerage and sanitation sector, and what Mission members look for during appraial with regard to the technical preparation of a project, its financial viability and institutional aspects.

SEQUENCE OF PROJECT APPRAISAL

9. Initial requirement by the Bank before a project is included in the ADB's lending program is that the project should fit into the development program of the DMC in question. MOst countries in the region usually prepare a five-year development program from which the Bank identifies a three-year forward program of projects suitable for Bank financing. Once a year Bank staff who are assigned to a specific DMC discuss with the government possible projects for Bank financing and update the three-year rolling program for the country. One of the major objectives of the review is to check whether the project is compatible with the overall development thrust of the country. Also, the Board of Directors of teh ADB and Management establish broad guidelines regarding the sectorial distribution of projects and the' advance three-year program is prepared under these guidelines.

10. Once a project is included in the Bank's forward planning program, and depending on the amount of information available, a check is made by the Bank on whether the proposed project is, at first glance, okay, that is – a quick look is taken at technical feasibility, financial viability and institutional capability – if the government concerned has only determined the broad outline of the project then the Bank can provide technical assistance grant funds for project preparation.[1] If the conclusion of this review is that the project has been well prepared[2] and that there is sufficient background information, data and analysis carried out to enable Bank staff to appraise all aspects of the project then normally a Fact-Finding Mission is mounted. At this stage all aspects of the proposed project (technical, institutional and financial) are covered in depth. Problem areas are identified and discussed with the proposed executing agency and government authorities and a report is presented to the Bank's Management with recommendations on any important issues. For water supply projects an issue which continually arises is the urgent need to increase water tariffs – often an initial increase is required just to cover present operation and maintenance costs. This is mainly because accounts receivables are usually high and getting worse and because one-third to one-half of the water supplied is unaccounted-for. Once Management gives its views on the issues, an Appraisal Mission is sent to to the project area to appraise the project.

11. The scope of the project and cost estimates are agreed upon between the Mission and the government officials concerned at the end of the Mission and as much agreement as possible is obtained on the issues. Following preparation of the draft documents which will be presented to the Board and which reflect the views of Management, formal loan negotiations are held (usually in Manila) between the Bank and the executing agency and government authorities concerned to resolve any outstanding issues and to formally reach agreement on the scope of the project and the covenants that are attached to the loan. If all issues are resolved during loan negotiations the project is presented to the Board for approval.

WHAT THE ADB LOOKS FOR

12. Though there are "ideal" data requirements in putting together any project appraisal the Bank recognizes that many government agencies are unfamiliar with ADB's appraisal requirements and often need help in preparing data. Within reasonable limits Bank missions are willing to assist agencies in compiling the data required.

TECHNICAL ASPECTS

13. The ADB normally requires that the project fits into a long-term development program and also that the relationship between technical and financial aspects be taken into account when establishing the basic parameters of a project. In other words, the project should be related to the ability fo the country and the served population to pay for the facilities, for example, the question of whether water should be supplied through standpipes or house connections.

14. Major components should be selected from all prima facie alternatives on well rounded technical arguments and by a comparison of the costs of the feasible alternatives.[1] Examples of alternatives that need to be evaluated are whether the development of available groundwater (which has a relatively low capital cost but high operating costs) is more cost effective than surface water which usually has a high capital cost but perhaps lower operating cost; or whether in a distribution system, where the water is pumped, large diameter pipes should be provided to reduce the cost of pumping or smaller diameter pipes and higher

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[1]In the case of major water supply or sewerage/sanitation projects for large city or regional development, the Bank can provide an engineering loan for preparation of master plan/feasiblity studies together with a grant towards the cost of the studies.

[2]If further project preparation is required then either the government concerned (or government agency) is responsible to ensure that the additional studies/investigations needed or the Bank can provide technical assistance grant funds up to certain limits to carry out additional studies/ investigations.

[3]An assignment given to the World Bank as part of the support for the Water and Sanitation Decade is the preparation of a handbook which will assist developing countries prepare investment projects in water and sanitation. The ADB has provided comments on the draft handbook and current planning is to have the handbook printed by the end of 1981. This handbook provides in some detailed the data requirements of international lending agencies.

pumping costs should be used.

15. Another important Bank consideration is whether appropriate technology has been adopted in the choice of water treatment processes, control and pumping equipment. And, for those water supply projects which do not include complementary sewerage/sanitation components a careful review is carried out of the environmental impact of the proposed project and – depending on the review – appropriate safeguards built into the project.

16. The Bank reviews the cost estimates to ensure that they are realistic and that adequate physical and price contingencies have been made. If the project forms only part of the expansion of a water supply system then Bank will require that the other components are identified and costed and that they also fit into the long-term development program. No project is ever looked at in isolation. The existing system is studied to see if anything can be done to improve the level of operation and maintenance. In recent years the Bank has placed much emphasis on the need for efficient control of distribution systems. In most urban areas unaccounted-for-water represents between one-third and sometimes over one-half of the water supplied. In view of this, the Bank insists that measures are taken to reduce high percentages of unaccounted-for-water to ensure that project investments are not wasted. To reduce unaccounted-for-water to acceptable levels requires a well coordinated program covering several aspects of a water supply authorities activities. It means ensuring that meters work efficiently and are read properly, that leakage detection programs are implemented with the correct equipment and that operatives receive adequate training, that a public information campaign is mounted on the need to curb training, that a public information placement and repair programs are developed for identified leaks and old defective pipelines. With regard to supply source works often the equipment in treatment plants and pumping stations is old, defective and inefficient resulting in frequent breakdown and unnecessary high energy costs. For several water supply projects Bank assistance has been provided for upgrading existing facilities and providing the needed equipment and the consultant services which are sometimes required to carry out related studies and training.

FINANCIAL ASPECTS

17. The Bank not only requires that a financing plan for the project (and the other parts of the expansion of the system) has been identified but that the financing is appropriate for the financial status (present and future) of the water supply authority. It also requires that separate accounts be made maintained for the project and that a generally accepted commercial type accounting system be adopted (as opposed to cash entry type) for the day-to-day operation of the water authority.

18. One of the most controversial aspects of the Bank's requirements with regard to water supply projects is regards tariffs. Normally ADB uses a financial approach when determining tariffs. One reason for this is that the social and economic benefits are not quantifiable. However, financial viability is often an indicator that the project is economically of the authority operating the water supply or sewerage facilities is often guaranteed, and this is considered to be an important means to achieve efficient operation and maintenance and to finance a reasonable portion of future expansion out of internally generated funds.

19. All Bank-financed projects include (within project loan documents) a covenant which specifies the financial criteria which determines the level of tariffs. The tariff covenant used in most water supply projects financed to date has been that tariffs will be set at levels to cover operation and maintenance costs, including depreciation, debt servicing and a reasonable proportion of the costs of future expansion. This tariff requirement may be strengthened or weakened depending on the relative financial ability of the community to be supplied to service expanded operations. In major urban areas normally the tariff is strengthened to require that a reasonable rate of return is obtained on net revalued fixed assets in operation (usually defined as between 6 and 8 per cent). In rural areas, where water supply systems are being developed for the first time, a phased approach to financial viability is adopted. The Bank recognizes that it is important, particularly in rural areas, to keep tariffs low initially so that the majority of the population use the new supply rather than the often polluted, but usually free, existing supply source. A vital factor in determining the most appropriate tariff level is the ability of low income household to pay – and this is examined carefully. While the percentage of income that a household is willing, or is able, to pay is seldom the same, limited evidence available from the Bank's DMCs shows that if the total water charges is kept below 3 per cent of household income there is usually little resistance to payment on utilization of an alternative, but often polluted, supply source. If water charges approach or are above 5 per cent then illegal connections, tampering with water meters and other methods of taking water become prevalent.

20. In large urban areas where there are reasonably sized industrial and commercial sectors and higher income groups, block tariffs are often introduced which with progressive changes for water consumption allows an element of cross subsidy to be introduced which enables water tariffs for low income consumers to be kept at reasonable levels. For the provision of water supply systems in rural areas, the Bank usually finds that the initial system has to be funded, at least in part, by an equity contribution from the government if the system is to be afforded by all potential users.

INSTITUTIONAL ASPECTS

21. Specific attention is paid to ensure that the Project implementation team is well staffed by experienced professionals. The same careful attention is paid to the general institutional strength of the water supply authority so that it can operate as a sound public utility. There are wide differences between countries with regard to staffing of water supply authorities. In some countries, to control excessive staffing the Bank requires that increases in staffing must be approved by the Bank, while in others the Bank sometimes insists that active steps are taken to fill vacant positions.

22. Staff training is often incorporated into loans. This may take the form of either overseas training of key personnel or setting up training courses given by individuals who are trained abroad. Whenever possible, long term staff development plans phased with long-term system expansion plans are encouraged. Specific areas such as accounts receivables and unaccounted-for-water are examined carefully and if high, which is often the case, stpes to reduce both are agreed upon.

CONCLUSIONS

23. There is a mixed reaction from water supply authorities about the appraisal requirement of the ADB. For some, particularly those for which a laon is under consideration for the first time, there is occasionally a reaction to the amount and depth of information required. For those authorities who have received more than one loan from the Bank there seems to be a feeling that the Bank's appraisal requirements are only what an efficient public utility authorities more quickly into making decisions on such aspects as tariff increases, and government agencies and institutions (schools, universities, police, army, etc.) who often represent a large percentage of accounts receivable paying for the water they consume. The objectives after all, of the ADB are to ensure that the projects financed are implemented correctly and on time, that operation and maintenance are efficient and that the water supply authority concerned is financially sound. These then are the objectives of appraisal which help ensure that the proceeds of a loan are spent with the consideration given to matters of economy and efficiency.

PROJECT MANAGEMENT REQUIREMENTS FOR WATER SUPPLY OF THE INTERNATIONAL LENDING AGENCIES AND THEIR EFFECTIVENESS IN THE DEVELOPMENT OF THE SECTOR

by KLAS RINGSKOG

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1. Introduction

What is project management? Webster's dictionary defines "management" as "the judicious use of means to accomplish an end." Further, a "project" is defined as "a planned undertaking." Project management then means a judicious way of executing a project and attaining its benefits. This is of paramount importance to the World Bank since the Bank will ordinarily only lend for specific projects. This contrasts with program lending where at the time of the loan its future use has not been well specified.

2. The Water Supply and Sewerage Sector

The Bank's first water loan dates back to 1962. The lending volume expanded rapidly in the 70's when the Bank, under Mr. Robert McNamara, gave greater attention to social sectors. The water supply and sewerage lending volume increased rapidly from an average of about US$100 million in the early 70's to about US$700 million ten years later. The banner year was 1979 when almost US$900 million were committed as loans or credits (See Annex). This amounted to as much as 9% of the Bank's total lending in that year.

Over the years the East Asia and Pacific Region has received a total of US$500 million, or some 12% of the cummulative Bank Group water lending of around US$4.3 billion. It is unlikely that the rapid lending will continue in the medium term, and it becomes ever more important that committed funds be used with maximum efficiency.

3. The Project Cycle

The Bank seeks to ensure the efficient use of funds through its project cycle. The first step is the *identification of projects* that support national and sectoral development strategies and are feasible according to Bank standards. Generally the feasibility of a project cannot be ascertained at the identification stage. Further project *preparation* becomes necessary where additional data are gathered and analyzed to ensure that the project meets projected demand at the least possible cost while being financially viable. The next step in the project cycle is the *appraisal* where the project is reviewed comprehensively and systematically from technical, economic, financial and institutional points of view. The appraisal report then serves as the basis for *negotiations* with the borrower. Successful negotiations results in a positive recommendation to the Bank Board and a Bank loan or IDA credit follows. The next stage in the project is *implementation* during which time periodic supervision is undertaken by Bank staff. Implementation is lenghty and usually requires five years or more. Afterwards works are commissioned and *operations* begin. The final step in the project cycle is the formal *evaluation* that the Bank carries out to learn from the project. The added experience should then help improve future projects.

4. The PROJECT Manager

The project manager has to concern himself with at least the technical, financial and institutional aspects of a project. He should be familiar with common *project planning techniques* such as critical path methods and bar charts since he coordinates the entire project. During the execution of the project the *procurement* of goods and services and the *contracting of consultants* become critical. Pr ocurement frequently causes more problems than expected with project delays. The Bank has recently updated its guidelines for the contracting of consultants so as to make them more accessible. Undoubtedly there is a large demand for more formalized training in these areas.

Frequently financial problems of the project-executing entity delay construction. Faced with financial difficulties borrowers will invariably slow down payments to contractors and consultants rather than stopping the payment of staff salaries. The construction side is thus obliged to suffer inordinately. The difficulties are compounded by the little financial sophistication of most project managers. A project manager will ordinarily have only a technical background and not even be concerned about the financial situation of the project-executing entity.

5. The Project MANAGER

Apart from the various project aspects the manager has to deal with a host of behavioral problems as well. Since he is a coordinator of many groups and persons involved, he has to understand the motives of all these people and make decisions that can be implemented with a minimum of friction. To minimize interpersonal conflicts a project manager needs to be familiar with effective styles of *communication, teamwork,* and *appropriate conflict-solving techniques.* The Economic Development Institute of the World Bank offers workshops in such behavioral techniques.

6. Training

Training of staff to operate the project facilities is vital and should be planned from the very beginning. Insufficiently trained staff often cause low capacity utilization or frequent breakdowns. It would be well to consider training of operating and maintenance personnel as one of the project manager's duties.

7. The World Bank's Assistance to Improve Project Management

The Economic Development Institute (EDI) has given three courses on Project Management in recent years, where about 100 senior staff have attended. EDI is anxious to achieve a multiplier effect of its courses and may repeat them on a regional or national basis. EDI welcomes any interest on part of the countries themselves to co-sponsor such training.

WATER SUPPLY AND SEWERAGE LOANS AND CREDITS (US$ MILLIONS)

FISCAL YEAR	PROJECT VALUE	PROJECTS	IBRD LOANS	IDA CREDITS	TOTAL IBRD IDA
1962	18.9	3	2.0	6.8	8.8
1963	4.8	1	.0	3.6	3.6
1964	98.1	3	.0	53.0	53.0
1965	61.9	2	27.0	6.0	33.0
1966	55.7	2	21.3	1.3	22.6
1967	5.6	1	.0	2.1	2.1
1968	97.3	3	42.0	.0	42.0
1969	69.6	4	29.5	.0	29.5
1970	62.6	3	18.5	14.0	32.5
1971	455.9	10	219.4	3.1	222.5
1972	163.1	4	68.7	10.0	78.7
1973	703.7	11	200.1	100.8	300.9
1974	478.7	8	149.2	17.1	145.1
1975	326.5	10	128.0	17.1	145.1
1976	807.0	11	246.5	88.1	334.6
1977	811.6	14	257.7	34.2	291.9
1978	1812.5	16	345.4	371.5	893.8
1979	2196.7	21	522.3	375.2	893.8
1980	1797.7	16	446.4	184.7	631.1
1981	1456.6	12	500.1	97.5	597.6
TOTAL	11484.5	155	3224.1	1048.1	4272.2

IBRD: International Bank for Reconstruction and Development, The World Bank
IDA : International Development Association, the World Bank's soft loan window

IBRD LOANS AND IDA CREDITS FOR WATER SUPPLY AND SEWERAGE PROJECTS BY REGION (US$ MILLIONS)

REGION	PROJECT COSTS	PERCENT OF TOTAL	IBRD LOANS	PERCENT OF TOTAL	IDA CREDITS	PERCENT OF TOTAL
ASN	1469.4	12.8	.0	.0	681.8	65.1
EA	471.8	4.1	164.5	5.1	74.4	7.1
EAP	1352.0	11.8	467.1	14.5	32.8	3.1
EMEMA	2730.5	23.8	877.1	27.2	198.0	18.9
LAC	4912.1	42.8	1463.0	45.4	19.2	1.8
WA	548.7	4.8	252.4	7.8	41.9	4.0
TOTAL	11484.5	100.0	3224.1	100.0	1048.1	100.0

AS OF 07/02/81

WATER DISTRICT INSTITUTIONAL DEVELOPMENT IN THE PHILIPPINES

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To fully appreciate the effects and benefits of the development of the institutions known as Water Districts in the Philippines, one must examine and understand the situation as it did exist. The situation which will be herein described was typical of the water supply situation for the Philippine provincial cities through the early 1970's.

The actual construction of most existing transmission and distribution system was completed in the late 1930's. As a result, these physical systems were designed and built to serve significantly smaller population and areas than those requiring service in the 1970's. Additions and extensions made to the systems as a result of the growing demands did not consider master planning or long range effects. Maintenance varied from none, at worst, to essentially inadequate, at best.

Only about one out of five of the people living within the service area actually received service from the water systems. Those fortunate enough to receive service generally had to contend with poor pressure and intermittent service. Seldom was the water available all day, and often it was available for only one or two hours a day. Whole systems were frequently shut down for many days due to equipment failures.

The systems were under the control of local or provincial governments and often suffered from the evils of political considerations taking precedence over providing water service. The systems were overstaffed and the personnel often were underqualified or poorly trained.

Revenues were inadequate. It was politically expedient to charge very low water tariffs and to cover any deficits from general funds. It is little wonder that funds were not available for expansion and modernization, since most systems could not even collect adequate revenues to meet operating and maintenance expenses.

There were, of course, exceptions where cities had a water system operated and managed by qualified professionals. They provided a plentiful water supply and generated adequate revenues. Unfortunately, such water systems were in the minority. The majority of the systems under local government control provided inadequate service, at a financial loss, to a small percentage of the population.

This situation changed dramatically in 1973 when Presidential Decree 198 was enacted. This was the enabling legislation which formed the Local Water Utilities Administration and adopted the Water District concept for local water system operations.

Presidential Decree 198 mandated the creation of a national agency charged with the responsibility of controlling and coordinating the program of improvements in the water supply systems in the provincial cities. The water districts, as the operating units are known, would be responsible for the actual operation and maintenance of the individual systems and would operate on a self-supporting financial basis.

The Local Water Utilities Administration, LWUA for short, was formed primarily as a relending agency with the added functions of providing technical, operating and training services and skills. At the same time, LWUA is charged with establishing standards for the water districts and then monitoring compliance by the water districts.

Loans were and are secured from international lending institutions. The loans are guaranteed by the national government and are relent, at reasonable terms, to the various water districts by the LWUA. These loans are based upon feasibility studies and are specifically for capital improvements and not operating expenses. The basic conditions of each loan are that the district should be efficiently operated, be financially viable, and must repay the loan in full with interest.

Water Districts are formed under the guidelines promulgated by Presidential Decree 198 as amended. Each water district is a semi-autonomous entity operating under the general guidelines and policies of LWUA and the specific policies of its local Board of Directors.

The initial step in the formation of a Water District is for the local government to express an interest in forming a water district. After procedural consultations with representatives from LWUA, a resolution is prepared and passed by the local government. This resolution formalizes the intent to form a water district and to turn the physical water system over to the district.

Nominations are solicited for members of the Board of Directors and submitted to the Mayor orç Provincial Governor, depending upon whether the old system is operated by the municipality or the province. The Mayor, or Governor, then acts as the authority in appointing the five members of the Board of Directors.

The Board of Directors is composed of 5 local citizens nominated by various sectors in the community on the basis of experience, abilities, character, interest and general standing in the community. They serve 6-staggered terms with 1 or 2 Directors being replaced, or reappointed every second year. The staggered terms provide for strong continuity in the Boards.

The Board members are all active in business, professions, or civic authorities and serve on the Water District Boards without pay as a community service.

The board is the body which receives the assets, records, and the physical system as turned over by the local or provincial government. (As one of the conditions for the turnover of the system most districts have accepted the employees of the previously government-administered systems). The most important duties of the Directors are to establish the policies for the Water District, hire a professional General Manager and then insure that management implements its policies.

The General Manager is then responsible for, first, hiring the key department managers, and, second, managing the daily operations of the Water District.

The organizational structure will vary from Water District to Water District depending upon the local water supply conditions and the size of the District. However, one aspect is common to all, in that a system of checks and balances is encouraged. District organization is separated between the customer accounting, or commercial groups, and financial reporting and management. This encourages uniformity in dealing with customer accounts and fosters sound fiscal operations.

Improving service is the immediate objective of the Water Districts while planning for long range improvements and developing institutionally to operate, maintain, and expand the improved systems. The many new customers receiving adequate service can attest to the effectiveness of this approach.

While few of the features of the Water District systems are unique to the Philippines, there are two which deserve special comment. The first is the almost total separation of Water District financial operations from the normal municipal, provincial, and national governmental budgetary process. Water Districts are to be totally self-sufficient in financial terms after an improved system is in place and operating. They support themselves almost entirely through user fees. This approach removes the Water District from the normal budget battle, where the water system almost always came out poorly in the past. The financial freedom from the political process greatly increases the chance that the Water District will have the funds needed for operating, maintenance, and future systems improvement costs. The financial discipline of being self-supporting in capital as well as operating costs goes a long way toward making sure that initial systems are not over-built and then allowed to decay.

The second feature which deserves special comment is the commitment of LWUA to foster and develop institutional strength on the part of the Water Districts. A system is only a good as its management and operations. LWUA has developed training and management assistance and review programs which systematically develop the Water District's ability to manage and operate the system. The programs have teeth in them, in that LWUA will not make funds available to a Water District that has not reached a certain stage of development. In addition, all loans by LWUA have covenants requiring continued management review and development.

LWUA training programs exist for Water District personnel ranging all the way from Water District Board Members to low ranking operations staff. LWUA management advisors visit the Water Districts on a regular basis and review institutional development progress with Board Members, the General Manager, and other staff. In certain cases, where a Water District has real problems, a LWUA Advisor may be asked to sit as a sixth Member of the Board. In these ways the Water Districts receive constant review and advice. They are not simply aided in developing a physical system and then left to sink or swim.

The value of the Water District as an institution can be seen in the continued improvement in water supply service, the numerous capital improvement programs being implemented, the sound financial operations of many Water Districts and the continued phenomenal growth in the number of Water Districts being formed. From the enactment of Presidential Decree 198 in late 1973 until mid 1981, just eight short years, over 170 Water Districts have been formed all over the Philippines.

This is all the more impressive when one realizes that as late as the end of 1978 there were only 70 Water Districts in existence.

The progress made has not been trouble free. LWUA has had to cope with explosive growth. From time to time its people have had to be like the school teacher who works hard to stay at least one lesson ahead of the pupils. Its strict adherance to standards and specifications has created problems in construction, where a more relaxed attitude has been normal. Normal optimism has led to timetables for development which could not be fully met.

Not all Water Districts have been fully successful. Some have been politicized. In some the Board of Directors and the General Manager have come in conflict over duties, responsibilities and prerogatives. Some have been mis-managed and have become financially distressed.

But institutional development continues, and the system is growing and maturing. As an indication of the maturing of the Water Districts, there are emerging "Godfather" Districts. These are large districts, usually with completed comprehensive improvement programs and with adequate financial and human resources. In addition to operating their own water systems, these "Godfather" Water Districts are helping newer or smaller Water Districts in their regions. This assistance includes resolving, operating or construction problems, as well as in acquiring materials and in training personnel.

This self help shows the full cycle importance of the Philippine institution known as Water Districts. They have improved the water supply service in the provincial cities, they are proving financially responsible and self-sufficient, and now are truly helping each other to meet the challenge of demands for improved water supplies.

FOREIGN CONSULTANTS

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1. Introduction

The specific role of a foreign consultant will differ substantially from project to project and from country to country, depending upon the project under study and the experience and ability of the technical staff of the agency or government for which consultation is being provided. This discussion will focus on the work in developing countries, although most of the discussion would apply when working anywhere in the world.

2. Client Relations

The primary obligation of any consultant is to recognize fully the position of the client and his official representatives. The consultant should work WITH the client, not FOR the client. Only by working together will harmonious progress be made and the end product be satisfactory. The staff of the client is generally well educated and thoroughly familiar with local conditions, customs and politics. Their qualifications and experience should be utilized to the fullest extent possible in fulfilling the project's objectives.

The objectives of the project must be clearly defined, as will be discussed later, and mutually understood by both client and consultant. Then it is the obligation of the consultant to provide the proper solution to the problem – economic, technical, cultural – even though the solution may differ from the consultants preconceived notions based on strictly modern practices in industrialized countries.

Most governments, and sometimes the international funding agencies, may require the foreign consultant to associate with a local consultant for work in the country, when local firms are available. Regardless of any governmental requirements, it is generally to the distinct advantage of the foreign consultant to associate with a local firm for many reasons. First, they have an understanding of the local conditions, personnel and general policies. Second, they have, or should have, a thorough knowledge of local standards, codes and regulations. Third, in addition to providing professional support, they are able to provide local support in the sub-professional and technical fields, such as surveying, drafting, clerical, etc., at a much lower cost for salary, insurance, customs costs, etc., than could the foreign consultant. And, fourth, they can efficiently provide local logistic support.

3. Scope of Work

A very clear and precise definition of the scope of work to be performed by the consultant is essential. All too frequently disagreement has arisen between the client and the consultant because of a difference in interpretation of the contract as to the services to be provided. The client's engineers and administrators generally have a good understanding of what they think the work should include, but, because they may not be familiar or experienced in the necessary steps and factors required to produce the end result desired, the scope of work is not clearly defined. Clarification and precise definition of the scope of work should be made during the final negotiation of the contract. It has sometimes been observed, however, that even the consultant's negotiators do not understand sufficiently how the work must be performed by the project team to provide the necessary definition.

Related to the scope of work to be performed by the consultant is the determination of what personnel and services are to be furnished to the consultant by the client. Again, these should be clearly defined; not only defined, but positively agreed to be furnished as specified, and on time. This pertains not only to personnel, materials, supplies and equipment, but just as essentially to the developing and furnishing of data, background information, exemption from customs duties, cooperation with other agencies, approvals, etc. The foreign consultant establishes his time schedule for completion of the project, and the cost to perform the services, on the assumption that the client will comply with the terms of the contract relative to what the client is to furnish, just as the client requires the consultant to comply. This has to be a two-way street.

4. Qualifications of the Consultant

The selection of a foreign consultant should be made after carefully evaluating and weighing such factors as:

- o Experience in the specific field of the proposed project.
- o Qualifications of the technical staff to be assigned to the project.
- o Qualifications and input of local engineering associates.
- o Experience in working on foreign assignments.
- o Thorough knowledge of the rules and regulations of the local and international funding agencies.
- o Reputation of the firm.

Experience in the Specific Field of the Proposed Project

This is self-explanatory. Because a consultant has broad experience in the design of highways and buildings, it does not qualify him as being able to provide efficient and problem-free designs for pipelines, pumping stations and treatment plants. A good design firm does not necessarily have qualified personnel for management and administrative studies, operator training, etc. The design of a sewage treatment plant requires somewhat different expertise than the design of a modern water treatment plant, and vice versa. In other words, it is necessary to ascertain that the firm being evaluated is qualified to perform the specific services required for the proposed project.

Qualifications of the Technical Staff

The project produced is dependent upon the quality of the engineering input into the project. The client should examine carefully the qualifications of the proposed staff for the project; with particular concern about the amount of time that will be devoted to the work by the senior professionals. In addition, the "track record" of the firm should be examined to determine if it has actually furnished the technical staff that is proposed. It should be realized by the client, however, that due to circumstances beyond the control of the consultant, such as sickness, resignations, etc., it is not always possible to assign the personnel proposed, but the reason for not doing so should be real.

The experience of the staff as a team is also important. The hiring of experienced people, however well qualified, who have never worked together, or possibly have not worked for the consultant, can lead to difficulties for the client as well as for the consultant.

Qualifications of the Local Associates

The naming of a local associate is meaningless unless the local group is equally well qualified to perform its part in the project. What that part is will depend upon the project and the experience of the local group. In the past it has often been difficult to find local consultants in some countries with experience nad with a permanent staff to provide all the assistance desired. This condition is improving as the local consultants are gaining experience, are becoming trained, and are able to find full-time jobs in their technical and geographical areas. Our firm has been very fortunate working in the Philippines to have excellent local consulting associates, both in engineering and economics.

Experience in Working on Foreign Assignments

The local conditions, which differ radically from country to country, have significant influence on the approach and development of a project, whether the project is a study, design, construction, or training. The experience of a consultant in working in countries of different cultures, varying development, and industrialization, can effect the approach to the project and the conclusions reached from the work. The experienced consultant will utilize solutions to problems that have been successfully used in other countries, particularly those of similar development and culture, to assist in the solution of problems from the client's project. A better understanding of local conditions will produce a better and more practical solution to the problems to be studied on the new project.

Knowledge of the Rules and Regulations of the Funding Agencies

It is essential that the consultant have a thorough knowledge of the rules and regulations of the agencies funding the project. Without an understanding of the requirements of the international and/or the local funding agency, considerable time can be expanded modifying or correcting decisions that have been agreed upon between the client and the consultant. Each agency has its separate regulations, and the liaison officer from each agency assigned to the project has his own interpretation of the regulations, which must be adhered to by the client and his consultant. The more experience the consultant has had in working on internationally funded projects, the less opportunity there is for serious disagreement with the funding agency's representatives.

Reputation of the Consultant

Based upon references from other clients – especially foreign clients and international funding agencies – an evaluation should be made of the consultant's previous overseas assignments. Was the work performed satisfactorily? Was it completed on time and within the budget? Did the consultant's staff work harmoniously with members of the client's staff, the funding agency's liaison officer, the local associate? Would the client retain the consultant again for a similar assignment?

5. Responsibilities of the Foreign Consultant

In addition to carrying out the contract terms, the responsibilities of the consultant are manifold. They will vary, of course, from project to project. There are, however, certain responsibilities that the foreign consultant should assume in almost every situation. Many are routine and obvious, but some are frequently overlooked or ignored. These include such tings as:

- Liaison with the client.
- Technology transfer.
- Responsiveness to local conditions and culture.
- Full utilization of local resources.
- Local financial constraints.

These points will each be discussed briefly.

Liaison with the Client

This has been discussed earlier, but it is important enough to emphasize again. It should not be necessary to mention this specifically as a responsibility of the consultant, but too often the project staff assigned to the job is so engrossed in getting the work done according to the terms of the contract, and within the time frame and budgetary restrictions, that the client and his representations are by-passed or ignored until time for the final approval of the consultant's work. This in inexcusable! It not only can cause resentment by the client, but can result in substantial delays and increased consultant's costs, to say nothing of producing a dissatisfied client.

Some neglect of this responsibility has been ascribed to the fact that the client may not have the technical or managerial experience to discuss or evluate the project, only the consultant having that expertise. This argument, if true, is not justified. This leads to the next responsibility.

Technology Transfer

It is the strong opinion of the authors of this paper that one of the major responsibilities of the foreign consultant, if not THE major responsibility, is to provide technology transfer from the consultant to the staff of the client and the staff of the local consulting associates. The consultant should be endeavoring to train the local engineers, managers, technicians, economists, operators, so that sometime in the future – although not necessarily at the conclusion of the specific project – a major portion of the services provided by the consultant can be performed by local personnel. Most of such technology transfer can be made on the job in the country where the work is being performed. However, it is frequently more advantageous to members of the local staff to arrange training for them outside of their own country, such as in the United States or Europe. This training can be, and has often been, included in the consultant's scope of work under the contract.

Excellent examples of technology transfer and close client liaison are available here in our host country, the Republic of the Philippines. They are evident in the two major agencies responsible for water and wastewater: the Metro Manila Metropolitan Waterworks and Sewerage System (MWSS) and the Local Water Utilities Administration (LWUA).

How this was accomplished is a study in itself and has been reported upon in numerous other forums. However, this has only been accomplished with the interest and full cooperation of the government officials and agencies – from the local level through the highest national level – and by the willingness and desire of the local engineering, technical, and managerial staffs to do the job right. They are to be sincerely congratulated.

Responsiveness to Local Conditions and Culture

The living standards, home life, community development, all should influence the direction that a study takes. As is the case in almost all activities – personal, group, community, or state – it is necessary to walk before you run. To avoid disasters the first steps must be small. Later, longer and larger steps can be taken to reach the desired goal. So it is with any engineering project. To go in one jump from a hand-carried water supply from a river or well to a pumped supply of treated water to each household could easily fail, not only because of its cost, but because the people would have great difficulty to make a practical adaptation to the new way of life, including the operation and maintenance of the new facilities. People accustomed to using pit latrines, or none at all, may not immediately accept modern plumbing facilities.

As a part of any major modification in the existing way of life in an area, the consultant should include in the scope of work to be performed an educational program for the local residents in that area. The success of many projects can be directly proportional to the local involvement.

Full Utilization of Local Resources

A survey must be made to determine what is available in the area in the way of construction materials, machinery and equipment, and local contractors available to construct any new facilities. Is concrete and steel readily available at a reasonable cost? What is the cost of energy – electric and diesel? Are water and wastewater chemicals available locally, or do they have to be imported?

Are experienced people available to operate and maintain properly the new facilities after they are constructed? If not, are there people in the area who could be trained by local agencies or by the consultant, either in the area or overseas? All of these factors must enter into the decisions made during the studies.

One of the most challenging tasks in the development of new projects is to adapt existing technology to meet the needs of communities and to make innovations to suit local conditions. The main criterion for selecting a system should be ability of the community to support the system in all respects. Factors that have a major bearing on the cost of the system, as well as on that of operation and maintenance, relate to design criteria, there should be flexibility to make modifications in accordance with local conditions.

Local Financial Constraints

One of the most critical parts of most studies of projects in the developing countries is to ascertain the financial status of the people living in the study area. What can they afford to spend to improve their living standards? Is a subsidy available, either local, state or federal? Can grant funds be obtained from one of the international funding agencies?

Almost without exception the concept of what is wanted – and needed – costs far more than the local economy can support. A compromise is generally required. Either the entire project is scaled down to an affordable size, or it is so planned that it can be constructed in stages as additional funds become available, either by improvement in the local economy, or from an outside source.

FOREIGN CONSULTANT'S PROBLEMS

Proposal Preparation

It would often appear that the potential client, and even the funding agency, may not be cognizant of the cost to the consultant to prepare proposals. It is clear that the consultant must prepare many qualification proposals in order to place his name, or keep it, before prospective clients. This type of proposal generally does not cost an excessive amount of money, for it is made up of more or less standard material. It is the technical proposal that can run into very high cost, if it is properly prepared. Such proposals rarely cost less that $10,000, and can cost well over $100,000. These costs must necessarily revert to some client, for it is an overhead item for the consultant.

To keep these costs to a reasonable minimum, and be fair to the consultant, the client and the international funding agency should keep the "short list" of consultants invited to prepare detailed technical proposals shorter than they are generally now doing. From the wealth of information currently available regarding the work and reputation of the foreign consultants, a client should be able to select three to not more than five firms for a "short list." This would provide adequate opportunity to select a firm that can provide the services required, and would not necessitate the expenditure of substantial sums of money by the consultant whose name may have been included on the "short list" merely to indicate the open-mindness of a client or a funding agency.

Delay in Start of the Project

A delay in the start of a project, after the submission of technical proposals, can cause serious problems for the consultant. Delays of weeks and months are frequent. They can occur in: (1) selection of the successful firm after submitting the proposals; (2) negotiation of the fee; and (3) issuing the "Notice to Proceed."

There are few consultants, if any, that have the flexibility to continue to have a designated staff available for a project which may not start for possibly a year after a proposal is submitted. The client insists, and rightfully so, that the consultant name the staff that will work on his project. This the consultant does after carefully considering the technical skill required to perform the services and the experienced key personnel he will have available to do this work at the time the project is expected to start. If the project is delayed, it may be necessary, possibly because of the cost factor, to assign the key personnel to another project, so they would not then be available as promised. The individual may have taken a job with another firm. Or family or health conditions may have changed so that he no longer is willing to accept the assignment. It is the consultant's desire to furnish the staff listed in his proposal, but sometimes delays make this impossible.

Disagreement Between Client and Funding Agency

The consultant is frequently in the middle between the client and the international funding agency. The consultant's contract is usually with the client. It is the client and his representatives who endeavor to convey to the consultant the local conditions, standards, policies, and politics that should be considered in the project planning. Frequently, however, the representative of the funding agency does not agree with the client on some of the major items, and insists that the project be modified to meet the funding agency's wishes. This may leave the client with what he considers an unsatisfactory solution to his problem, and/or could require additional work by the consultant not counted on during the contract negotiations.

What should the consultant do to help keep this situation from developing? At the beginning of the project, before any substantial amount of work is done, the consultant should make every effort to get together with him the responsible representatives of the client and the funding agency to establish the basic criteria and ground rules to be used. The results of the meeting should be reported in writing and signed by all parties, so that later disagreements can be kept to a minimum, even if the various representatives are changed.

SUMMARY

The foreign consultant's role should include:

1. Maintain close liaison with the client and his official representatives.
2. Provide an affordable project, both from a construction and an operational standpoint, that is consistent with the local culture.
3. Provide a project that can be operated and maintained by a properly trained local staff, and provide the necessary training.
4. Maintain a concerted technology transfer program from the consultant to the staffs of the client and local consultant associate.

LOCAL CONSULTANTS IN DEVELOPING COUNTRIES

by LAMBERTO UN OCAMPO

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In a gathering of eminent water supply engineers (such as we have today) I suppose that it is appropriate to start out this short paper by relating to you the story about a "ditch digger."

It seems that a young waterworks engineer went on a field inspection of a pipe laying job somewhere in the busy section of the city. For several minutes he stood by watching an old laborer furiously digging a pipe trench, totally unmindful of the hustle and bustle around the work area. There was the heat of the noonday sun; the noise and the smoke belching out of the stream of vehicles passing by, the dust stirred out of the rutted pavement, and the peering eyes of the curious pedestrians.

Shortly afterwards, the twelve o'clock whistle blew, signalling the lunch break. The old man dropped his shovel and picked up his meal – which was nothing more than boiled rice, topped with dried fish, a small tomato and all wrapped up in banana leaves. At this point the young engineer mustered enough courage to ask "Mister, why are digging ditches? "

The old man visibly irritated by the sudden interruption curtly replied, "Young man, if you must know I dig ditches so I can earn enough money to buy food – such as this – which I can eat to let me gain enough strength and energy so I can continue digging ditches."

I mentioned this brief anecdote because of the parallelism between the laborer in the story and the local consulting engineer who is just starting out to practice in an under developed country. In a manner of speaking, they are both "ditch diggers" – working, slaving day to day and hardly eking out a hand-to-mouth existence.

BEGINNING OF CONSULTING ENGINEERING IN THE PHILIPPINES (1945-1965)

Prior to the second world war, there was hardly any privately-owned engineering consulting firm in the country – if at all, it is questionable whether they could have survived. Not that there was lack of work to do – for there was a plenty, as both the government and private property owners were in a frenzy of building, rehabilitating and renovating the war-ravaged nation. The sad fact was that the hapless consulting engineer had to pursue an elusive client who was yet uneducated in the ways of consulting engineering practice.

There were six easily identifiable types of clients that emerged during that rehabilitation period and they can be classified according to how they managed to embark on their building and rebuilding programs.

1) The Government Agency with its own "in-house" engineering staff that could undertake studies, designs, supervision, and occasionally the general construction itself. Most of the administrators at that time felt – and some still do – that this was the most time-expedient and economical thing to do. Expedient probably but it has yet to be proven that this is more economical. At that time the private consultant was too weak to register even a feeble protest so he was left on the outside looking in.
2) Next was the government entity that had the engineering know-how but not the funding for its projects. As a matter of course it ran to international lending agencies for money to fund infrastructure programs. As is usually the case, the banks had to assure themselves that their investment was protected and therefore required the borrower to abide by the so called "golden rule." "He who brings the gold also specifies the rules." Naturally a foreign consulting firm had to come into the picture and take full charge of both the design and construction supervision. The menial drafting, minor engineering and estimating jobs was entrusted to the government

employed engineers and the poor independent consultant was once again left out holding an empty bag.

3) The third classification is also another government office that had absolutely nothing but a work program. It didn't have enough assets or real property to serve as a collateral for loan purposes. This particular agency had therefore no recourse but go "beg" for bilateral "aid" from the more affluent and friendly countries. In more cases than we care to remember, there were several strings attached to the supposedly "UNTIED AID." But beggars, so they say, can't be "choosers" so, even if this one government office wanted to hire local consultants (which was questionable) it would not have been possible under the terms of the bilateral grant-in-aid.

   Whether it is still a requirement or not, I do not know but, there was a time when the UNDP, would offer technical grants only if foreign consultants are utilized. The rationale being that if such expertise was available within the requesting country, this would be a disqualification from receiving such technical grants.

4) The private home owner/small time businessman: this peculiar client did his construction often without plans, building permits and adequate funds. He would do things himself or with the help of neighbors and friends. Surely this class of client was not worth cultivating because even if he was willing to give the job, he probably couldn't afford to pay anyway.

5) The middle income private client can afford to be a bit more choosy – he can and would often go to a General Contractor or a Master Builder who, in turn, engaged unemployed or under employed engineers to undertake the job. Taking advantage of the situation, the turnkey contractor would then pay the engineer (figuratively and literally) peanuts! I happen to know that this has not always been the case, sometimes the designers got paid in home grown chicken or vegetable or "approved equal."

6) The more sophisticated and forward looking businessman/industrialist was somewhat different from the rest. For commercial buildings or factories he went to an Architect who would act as the prime professional. The Architect runs to the City Hall and seek out the same engineers whose duty was to review and approve the Architect's plans. The government-paid engineers will moonlight for the architect to prepare necessary plans and specifications which they will themselves subsequently review and approve. This was a very neat and convenient arrangement that once again left out the independent private consulting engineer without any professional arrangement.

Such was the picture of consulting engineering practice (or lack of it) during the first two decade after World War II. Nearly all engineering design and/or supervision jobs went to professionals who were employed in government offices. The little that was left to the private sector paid so meagerly that the practicing consulting engineer was, in a real sense, a plain and simple "Ditch Digger."

DEVELOPING THE CONSULTING ENGINEERING MARKET (1965-1980)

The Consulting Engineer in the second half of the sixties was at the crossroad of his career. If he choose to continue "digging ditches" he might as well be digging his own grave. Would he perhaps like to dig holes instead? So that water or gold or whatever can be mined from the bowels of the earth can be his for the asking? The choice was an easy one.

First he looked over the six types of clients and went about trying to develop them into paying customers. He also studied ways on how to reduce the chances of traditional competitors from getting the jobs away from him.

1) The government agency which tried to do everything "in-house" was talked into realizing that there were alternative ways of doing things more economically and efficiently with lesser headaches and heartaches for the implementing agency. This also resulted in some of the more competent government engineers (who were rendered redundant) into retiring and being hired by the private consulting firms.

2) The government entity which used to be coerced into retaining foreign consultants conceded and made it a requirement to maximize use of local engineers in an effort to reduce engineering costs. This was done by encouraging the expatriate firm to nominate Philippine Engineers as either sub-consultants or joint venture partners in all phases of the work. This happy arrangement gave the added feature of providing the local touch to the project. . . and, at the same time, allowed some transfer of technology to the local engineers who will be left to someday maintain, expand, or renovate the facilities.

3) The bilateral aid from the more affluent nations had to cut some of the strings attached to their grants. If at all, the foreign firms were limited to the feasibility phase. The government though bilatedly made it mandatory to require Filipino partners for the design and supervision work in all the

loan-funded projects.

4) Soon employment opportunities on the construction of individual houses and shops opened up. The mortgage companies who lent long term money for low cost mass housing projects required plans, specifications and estimates to be signed and sealed by professional Architects and Egnineers. Limited research and development work was started by the more enterprising consultants resulting in better built and less costly residential units. The various utilities and amenities to complete the community also necessitated engineering work on facilities such as roads, waterwork systems, drainage, sewerage, power distribution, parks, playground and related community buildings.

5) The turnkey contractor who used to give "free" engineering services was only too happy to get away from his predicament. The design and inspection being taken over, (and rightfully so) by independent consulting engineers and architects, his expertise and responsibility was thus concentrated on building construction. The client was likewsie favored because, for the first time, he could shop around for the best bid or tender – where everyone (contractor and specialty sub-contractors) had to offer the least price and best quality work if they had to win jobs and stay in business.

6) The Architect who used to allocate a very small percentage of his professional fees to the structural, electrical, mechanical and sanitary engineering consultants was repeatedly worked on until he agreed to a more reasonable inter-professional fee distribution.

This was by far the most difficult undertaking since everytime the engineers' fee was increased, it had to be taken out of the architect's share of the fixed percentage fees.

In brief, the consultants got tired of waiting for opportunity to knock on their doors, they created their own opportunities. Local engineers started concentrating their marketing efforts towards industrial projects where they became the prime professionals. The Architect who used to lord it overall construction jobs was relegated to the role of a "sub" on the minor aspects industrial projects such as the office, cafeteria, color schemes, the gate house and the landscaping.

At about the same time as this was ongoing, the government infrastructure program began to accelerate in earnest and some of the implementing agencies such as the Ministry of Highways and the National Electrification Administration, (to mention a few) insisted that the local consulting firms have"come of age" so they could be the prime professional. The Filipino consulting firms were left with the decision of whether or not they needed the services of individuals or foreign firms for the more sophisticated technological requirements of the project.

Simultaneous to these moves some of the more established engineering firms made efforts towards expanding their scope of services. Completely new divisions were created such as (1) project and/or construction management (2) quantity surveying (3) value engineering (4) energy audits (5) environmental impact statements (6) economic and financial studies more are coming.

CONSULTANT'S SHARE OF PROBLEMS (1980)

After the consultants have developed the clientele and upgraded the fee structure and were on the way to say they have "arrived" at the second phase of development of the consulting industry a new and more serious problem arose. The building boom in the oil rich countries and the consequent brawn and brain drain descended like clouds on the country.

The Filipino has always been foot loose and adventurous. He had the advantage of being schooled and being fluent in the English language. When the opportunity came for the need for Engineers and construction workers the Philippines, more than any other developing country began losing engineers, architects, draftsmen, carpenters, masons, pipe fitters, welders, drivers, and even house maids by the tens of thousands. The exodus of engineers to American, Korean, and European firms for assignment to the Arab countries is worsening week after week.

It appears that everyone (even the government) was powerless to stop the exportation of Philippine manpower. The irony is that we were giving away our most important resources, people – to international competitors, while we remained proud of the fact that this was our one single advantage over the other countries seeking work contracts in the Middle East.

In construction as in consulting work – this is a big drain that we can ill afford. What was worse was sickening was that local business cannot come near, much less match the pay that the foreign competitors were offering. The government came in too little and too late with toothless restrictions that didn't stem the tide of the outflow of professional engineers. The Filipino is supposed to have the inherent right to unrestricted travel and choose one's own employer. We haven't found a suitable solution to this problem and we doubt whether anyone can.

A few of the consulting outfits have started to do something, like getting involved in design work for local and foreign consortiums working or subcontracting abroad. This had to be done only to present an alternative to our adventurous people who think the grass is greener on the other side of the pasture. In addition this may assure us that when they get tired of working overseas goal for Philippine Consulting and construction firms is to export services rather than export people.

Despite the grave problem of losing engineers to other countries, we might truthfully say that the consulting engineering firm of today never had it so good. The government has started to use local consultants almost to the exclusion of the foreign firms except for the more sophisticated technology. The engineering fees, though not nearly as much that charged by foreign consultants, are livable. The Architects and some government agencies have seen fit to stay away from hiring their own in-house engineering staff and they have gradually agreed to a fee structure that seems acceptable to most.

The Consultants have successfully graduated from digging ditches. They have since dug wells and water is gushing forth continuously. Some holes have even yielded gold – so that some lucky engineers have paid the mortgage on their own houses – matter of fact, a few are thinking of buying a second home – with probably the attendant "second wife."

WHAT OF THE FUTURE? (1981 and Beyond)

The question that remains in the minds of local consultants is "where do we go from here? " Soon the government infrastructure program will dry out. The construction projects in oil rich countries which is presently booming may go "bust." With most of the Philippine budget going to the importation of oil, funds that should have gone to private and public construction (and with it engineering consultation) – is getting smaller and smaller while the number of firms are getting more and more.

The decade of the 80's has just started and is full of challenges. The innovative consulting engineers in developing countries such as the Philippines must ACT NOW to meet these challenges. . . they must continuously train men with pioneering sense of adventure and (what is more important) – find ways of holding on to them.

We must keep on improving our stock of human resources and brain wash them into believing that their only goal is to exceed and to excell and they must repeatedly be motivated to do the best they can. We have such men in our country and in our firms – in practically all the disciplines and in various levels; engineers with pride and a pioneering spirit, foot loose and willing to work in unfamiliar environments, innovative people with ambition and a desire to do better than the arbitrary goals set by time, tradition and man made programs.

As we look back to the past, we like to think that Local Consultants have gone from *ditch digging* to *digging for treasures of the earth.* Mind you, we have also *dug holes* that (we hope) will never dry up (like some oil wells) for in the holes that we have dug we have also planted trees – a renewable resource – and they are now showing signs of bloom. Soon we can expect a bountiful harvest, season after season.

Despite the many problems confronting the industry we know it is close to reap what we have planted and we hope that this is the beginning of the take-off stage in the development of Consulting Engineering practice in our country.

CLIENT-CONSULTANT WORKING RELATIONSHIP FROM THE CLIENT'S POINT OF VIEW

by PRIMITIVO H. ALAVA — Asst. General Manager for Engineering, Local Water Utilities Administration

TEOFILO I. ASUNCION — Project Manager, Metro Manila Sewerage Project, Metropolitan Waterworks & Sewerage System

A INTRODUCTION

In the few years of working with Consultants, both foreign and local, we have some nice and some not so ideal relationships with some of them. Of course, the good is more than the not so ideal. This could be compared with buying "balut" or what a friend from the World Bank called "pregnant eggs," by the dozens. While expecting to get your money's worth, once in a while, one gets bad ones mixed with the good ones.

Client-Consultant relationship may be similar to the relationship between doctors and patients. Ideally, the relationship should be one of mutual trust and confidence and with high respect for each others responsibility and role. Sometimes, a doctor may prescribe a bad tasting medicine which the patient could not stomach. The doctor should not be penalized for this but instead he should be judged on whether the patient gets well on time and at what costs.

B. CONSULTANT

A Consultant is a Specialist in a particular field of activities who provides extensive and diversified professional services and advice to his client. He is an experienced person with ability to take an overall view of a given situation, examines and analyzes the problems, identifies deficiencies and recommends appropriate solution. He should possess sufficient academic and professional qualifications back up with years of experience on the particular field for which his services are required. We believe that only after a reasonable period of solid and practical experiences should someone be ready to provide professional services or advice as a Consultant.

A Consultant should be able to express himself clearly both verbally and in presenting comprehensive and lucid reports and recommendations. He should express himself in as simple as necessary and in concise presentations not in bulky reports and documents as quality of service is definitely more important than quantity.

His services must be carried out in a competent and efficient manner, and in an atmosphere of mutual trust and apprecaition and the same must be performed on a highly ethical plane.

C. NEED FOR CONSULTANCY SERVICES

Consultancy services are needed when someone wants to assure himself that he needs a "state of the art" opinion on how he should proceed to achieve his objectives. He may want an independent and unbiased views and a high degree of professional services of implement a project. He may want to have transfer to technology to strengthen in-house staff capability.

It is less expensive to hire Consultancy services for a short period of time rather than maintain a group of professionals in the staff on a permanent basis. It is not advisable to hire and fire professionals depending on the needs. It is more convenient to hire Consultants on temporary basis to do highly specialized works and have the day-to-day activities handled by in-house staff.

Lending institutions would normally require borrowers to employ Consultants whenever the latter's own expertise are judged to be inadequate for the task at hand. This is to assure that the work will be performed to the highest standards and in a very objective manner.

D. PROCUREMENT ON CONSULTANCY SERVICES

Generally, the initial steps in the procurement of Consultancy services are preparation of Terms of Reference and compilation of "long list" of Candidate-Consultants. The listing may come from international lending institutions and development organizations, embassies, technical magazine, other agencies and from Client's own file.

The next step is the preparation of the "short list" of Candidate-Consultants taking into consideration applicable experiences, capabilities and reputation of the firms. Invitations to submit technical and financial proposals in either one or two envelopes based on the Terms of Reference, are extended to those Firms in the "short list."

Technical proposals and sealed financial proposals are submitted at the same time. Normally, the technical proposals are evaluated and ranked by a Special Evaluation Committee created by the Client for the purpose. Some of the criteria usually adopted by the Committee include experiences and capabilities of the consulting firm, quality of the technical proposals, and personnel.

Subsequently, once the ranking of the technical proposals are established, the financial proposal of Firm ranked no. 1 is opened by Client's Special Negotiating Panel usually in the presence of the Firm's representatives. This proposal becomes the basis of the financial negotiations.

E. RELATIONSHIP WITH THE CONSULTANT

The relationship of the Client with the Consultant starts with the financial negotiation or discussion of the costs of services to be provided.

In several of these negotiations, we have observed that Consultants are not only well-trained technicians but also well-rounded businessmen. In one of the financial negotiations, we requested the representative of Firm ranked no. 1 to justify his proposal but before doing so, he made a nice speech saying that the Philippine Negotiating Panel is different from the Panels of other countries. Allegedly, in other developing countries, the Client's Panels must be given the chance to reduce costs during the financial negotiations in order to reflect that members of said Panels are tough negotiators. Consultants would, therefore, propose higher costs in these countries in order to have plenty of rooms for reduction. He said that it is not the same in the Philippines, so the cost proposed by him were all "meat and bone" and without any "fat." When the members of the Client's Panel saw the financial proposal, it was quite apparent that the Consultant had a substantially different idea as to what constituted "meat and bone" as opposed to "fat." We can say that there was a lot of something between bones which were not all meat.

We made inquiries with our friends in such other developing countries and we were informed that the same "Modus Operandi" is being used to them.

We know that consulting services are practiced on a very high ethical plane, and that Consultants are hired more on experience and qualification rather than cost. We have experienced, however, that while negotiating the cost of the services with Firm ranked no. 1, Firm ranked no. 2 kept on knocking at the door saying that they can provide equal or better services at 25% cheaper. This unethical attitude of Firm no. 2 is good for the Client but one begins to doubt if ethics is still practiced in this field.

We have also experienced in one of our financial negotiations that the lead firm in joint venture would propose a management fee for managing a group of Consultants including its very own personnel, even if the Joint Venture arrangement was proposed by them in the first place. We find Joint Ventures to be useful on a case-to-case basis but in general, the concept tends to be expensive because the group would have a governing committee, the expenses of which are passed on to the Client.

The fee for consulting services depends on the types of services provided. The most commonly used in the Philippines is the basic salary cost times a multiplier plus reimbursement of out-of-pocket expenses. The multiplier includes basic salary, overhead, social benefits, allowances and profit. We have cases where Consultants would submit basic rates of Experts on category basis which are not the true basic salary of the employee. The ranges of actual salaries in the category basis are usually wide and the rates used for billing purposes are based on averages of the actual salaries of the Experts in the category. It is "give-and-take" affair in the sense that if the actual salary of the Expert fielded is below the average, then Client will be paying more and vice-versa.

The overhead will include everything one can think of in this world ranging from expenses of the Board of Directors to expenses of trying-to get new projects.

Social charges is another thing. Social laws of the country of the Consultants are always passed on to the Client. We have a case wherein we agreed to pay taxes to the Experts, considering that the new tax law in the country of the Consultant was passed while the consultancy agreement is in force. These new taxes, however, are considered additional income of the Experts and, therefore, are also subject to tax. This "tax on tax" is passed on to the Client.

Some firms even proposed allowances for Expert who will be sent overseas. We are wondering why a firm operating overseas would have Experts who would demand allowance when they know from the very beginning that to work overseas, one should leave his country. On the other hand, when the same Expert has completed his assignment, he would again demand an allowance for returning to his home country.

F. PROVISION OF CONSULTING SERVICES

At the start of the services, the Client would make it sure that Consultants are given a nice and air-conditioned office with new furnitures and cars. These amenities are naturally more than what is normally provided for by the Client to its own staff.

While working with Consultants, we have varied experiences, some of which are enumerated below:

1) During the submission of proposals, the Consultants would normally propose highly qualified Experts. In actual project prosecution, these personnel are replaced, and in some cases, more than once. Sometimes, key personnel are pulled out even if the project is still on-going. We have even cases wherein personnel is proposed to three different projects within the same period of time. It is very obvious, that the firm does not really intend to use him in any of the projects.

2) Some Experts who are assigned on full-time status on a certain project are given additional assignments elsewhere, yet are still being billed full time in the project. This practice sometimes causes delays in the prosecution of the project.

3) We noticed that some key personnel of the Consultant are not actually doing the work. The work is being assigned to Junior Engineers.

4) We have cases wherein contract drawings do not tally with contract documents and specifications or vice-versa causing some problems with the civil works contractors and consequently delays the project. Line surveys are sometimes not actual or accurately done on all streets or roads within the project area. In several occasions, there are streets shown on the plans but actually do not exist in the project area. This brings us to conclude that portions of the submitted plans were just copied from the proposed development plan of the city or municipality.

5) When Experts assigned to do a specific task, say a design work, are changed, design schemes of that particular task are also changed as often as there are changes in the manning. This does not only involve additional cost but also causes delays in the completion of the project because the new Expert will spend time digging the records of the previous Experts, familiarize himself to the task and usually his first act would be to change the design horizon.

6) We have cases wherein hundreds of existing pumping stations had been visited and some dozens of schemes submitted and the Consultant was still "gropping in the dark" for the best solution. The Resident Manager does not agree to any of the schemes presented and there was a feeling that he does not know what he wanted.

7) We have an Expert who is a good Design Engineer and came to Manila with a wife who turned out to be Wife no. 2. Later, Wife no. 1 came. How he managed the family is beyond our knowledge. However, this Expert would work up to late in the evening and would even work during weekends. After completing his assignment, he went home with Wife no. 3. He left his company since then. Now that the project is under construction, we have come across many things overlooked during the design. The change order required additional cost to the Client and delays in project implementation. We are coming to realize that his family problems could have possibly affected his work.

8) Transfer of knowledge and technology is one of the objectives of procuring Consultants services. Sometimes, this could be a three-way affair with the foreign and local Consultants and the Client. Foreign Consultants usually think that they know better than anybody. We have several cases wherein the details of the study is kept as a "top secret" by the foreign Consultants themselves.

9) We have a case where a foreign Consultant has to work in association with local Consultants. The term of reference calls for the former to oversee the design work and augment the services where the local Consultant is deficient. There was a time when the Consultants could not agree on whose name should come first in the title of the plans. The local Consultant insisted that the title should read: "The local Consultant in association with the foreign Consultant" since they were principally involved in the preparation of the design. They were like movie stars with "billing" problems. Result, the Resident Manager of the Consultant was replaced for failure to solve the problem internally.

10) In reviewing the composition of Consultants on a project-to-project basis, we noticed a mixture of nationalities composing the working team in the Philippines. In some cases, the Resident Manager, who is the leader of the team of Consultant, has different nationality. Like an American firm with a Resident Manager from Canada; firm from Switzerland with Resident Managers from Great Britain and United States; a Danish firm with a Resident Manager from New Zealand or an

Italian firm with a British Resident Manager. There is nothing wrong with this set-up. However, we have incidents which again are isolated and cannot be generalized, that some members of the team are not happy working with a boss from other country.

11) We had a Consultant from the land of the Beatles who does not like music while working our Office which has a piped-in music. He would come to work with a coat and tie when he knew very well that our Office is not yet air-conditioned and later on complained about the heat.

12) We have a Consultant who came in 1975 with a model 1967 car. We inquired why he brought a very old model car. He said that before leaving for assignment in the Philippines, he tried to sell his car for $500 but nobody wanted to buy it. He shipped the car to Manila. After finishing his assignment, he tried to sell the car in the Philippines for P5,000. Again nobody wanted to buy it. He shipped it back to his country. Of course, Client paid for the freight and insurance of about $1,000 or twice the cost of the car.

13) In the replacement of Experts during the execution of the project, Client is sometimes at the mercy of the Consultants. In most cases, the Consultant will only propose one candidate for replacement leaving the Client with no other choice. We are aware that biodata is not a guarantee that the Experts will perform well. The Consultants should know their personnel better than anybody else. We have experienced, however, approving the fielding of personnel proposed by the Consultant as Resident Engineer in the construction of a dam project in the mountain. When the personnel reported for work, we discovered that he is physically handicapped.

14) We know of a case in other Government agency wherein the service car provided the Consultant was not brand new, and the springs in the back seat kept on punching out. The driver was just putting plastic tape to keep the springs down. One afternoon, as the Consultant was going out of this car, his pants was caught by the spring and was ripped off. The next morning, the Consultant requested reimbursement of P60.00 for the cost of his pants.

15) We have noticed that the hierarchy of project organizations of the Consultants are usually top-heavy. While the organization of the Client follows the pyramid type of organization, the Consultants tend to reverse the same. In some projects, the Consultants have Sr. Vice-Presidents, Vice-Presidents, Assistant Vice-Presidents, Department Managers, etc. working on the project which is similar to having more generals than soldiers in the battle field.

16) Language can be a problem. We have experienced working with English-speaking Danish, French, Italian, Australian or even Englishmen and Americans. Some of them feel that Filipino English is not English. We know of a case where a Resident Manager who just arrived with his wife dined out one night in one of the restaurants in Makati. When offered drinks, the wife ordered a bottle of beer and the husband said, "Me too." The waiter came back with three bottles of beer, one for the wife and two for the husband. The husband complained that his "english" could not be understood in Manila.

17) Wives of Consultants are sometimes a problem too. We had a case where the husband was occupying a very responsible position in the project. To please his wife, he hired a driver, a cook, a laundrywoman, a housegirl, and a gardener. Results, the wife became bored doing nothing but eat and sleep and she decided to go back to her country. They tried to live separately for a while but ultimately the husband had to leave the project for fear of a divorce.

G. THE BRIGHTER SIDE

Our relationship with the Consultants has also the brighter side. We find plenty of positive aspects in working with them in most of our projects.

We have noticed that the presence of Consultants in our undertaking provides incentives to perform better. It gives our staff a challenge to compete with them and prove local capability.

Foreign Consultants provide a vehicle for local professionals to gain greater exposure to the latest technical innovations so that engineering problems associated with the project could be analyzed and solved with greater depth and breadth.

Consultants are sometimes used as scapegoats when things turned out to be unpleasant. We recalled to mind that in biblical times, the sins and ills of soceity were ceremoniously placed upon a goat which was sent off to the wilderness to carry the sins and ills away. Similarly, sometimes the ills of project implementations are blamed on the Consultants. They may be used as scapegoats but most of them never go to the wilderness.

DEVELOPMENT OF FEASIBILITY STUDIES AND DESIGN OF WATER SUPPLY PROJECTS WITH RESPECT TO WATER RESOURCES

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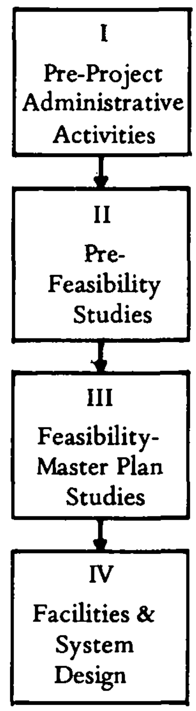
As set forth in the announcement of this conference, two major objectives have been defined:

1. Demonstrate an awareness of new potential technologies which may be adapted for local applications.
2. Demonstrate a commitment to pursue the objectives of the drinking water and sanitation decade.

On the basis of my personal experience in the conduct of feasibility studies for water supply projects internationally, I feel the technological methods and techniques available today are reasonably suitable for most locations particularly with respect to water resources. The purpose of this paper, in the context of the objectives of this conference, is first to provide an awareness to a recurrent feasibility study procedural problem, second to suggest why this problem may occur, and third, hopefully, give some recommendations which may be useful in correcting some of the persistent problems which occur with respect to defining new sources for water supply projects.

Usually, the flow of activities leading to construction of a new water supply for domestic-municipal systems is as follows:



Activity III (Feasibility-Master Plan Studies) is the portion of the overall program where emphasis is placed in this discussion, although Activities I and II frequently contribute to the problem being addressed.

Feasibility-Master Plan Studies as defined in Project Terms of Reference and Contract Documents, in many instances, include four general categories of study to be accomplished.

A. Evaluation of Existing Condition.
B. Feasibility and Master Plan Engineering.
C. Financial Studies.
D. Organization and Administrative Studies.

The additional or new sources of supply for a proposed new system are usually addressed and considered in Item B (Feasibility and Master Plan Engineering) and additionally, are treated in a manner similar to known, engineered, or calculated factors. However, in many project locations, the real condition is that water resources availability is not known and they cannot be engineered or calculated simply because necessary data are not available. This is particularly critical in remote unexplored areas where new water supply facilities are planned.

An examination of Table A reveals that Chapters I through IV and Chapter V through Item 5.02 can effectively be completed without information concerning new or expanded water resources availability. Most data necessary to complete these earlier chapters can be obtained from official maps and files, discussions with local authorities or brief field visits.

Chapter V, Item 5.03 (Additional Sources of Supply) evaluates and determines the quantity, quality, location and reliability of the new water sources available to the planned supply system. Further, it can be noted that all following items and chapters of the report are heavily dependent upon the very factors which must be determined with regard to new water sources. In effect, design, cost estimates, financial studies, etc., cannot be efficiently conducted without clear knowledge of the location and viability of additional resources. Unfortunately, clear knowledge of the location, reliable amount, and nature of required new water is not always forthcoming as a result of only a few days or perhaps weeks of study allotted in feasibility-master plan budgets. Thus, a resources problem may develop which causes significant project delay and waste of funds, as well as dissatisfaction on the part of all concerned. Table A, incidentally, was taken from a project report authorized in 1971 for a community of approximately 200,000 people. The water resources could not be clearly evaluated in early study phases and project delays have continued to this day. Although the new water source could not be determined in this case, assumptions were made, preliminary design was completed, and financial and organizational tasks were completed. It is obvious that essentially all study efforts conducted on design, financial and organization analyses were useless without knowledge concerning the system water source for this project.

From the example noted, it can be easily observed that if major changes occur in the new source location or character, a great deal of time and funding can be expended to develop invalid results which must be modified at a later date. In short, this procedure is wasteful.

It may be of interest to explore, briefly, some of the reasons why and how such wasteful procedures may evolve. In my own experience and analyses, at least one of the following four factors has been involved:

1. Poor knowledge of what water resources studies are and require.
2. Invalid assumptions regarding the availability and/or importance of water sources.
3. The limitations of resources evaluations in unexplored or undeveloped areas.
4. Inadequate or poorly prepared budgets, both in time and funding.

Each of these factors are briefly discussed to clarify their potential project impacts.

Poor knowledge of what water resources studies are and require is frequently reflected in terms of reference for a project. In many instances, such documents consider resources evaluations to be similar in character to water system analysis and design. This is both philosophically and practically erroneous. Water system requirements, facilities and components can be and are conceived, designed and constructed by people using well understood physical laws, theories and engineering techniques. Water resources are, on the other hand, a product of nature. Mankind did not conceive them, design them or construct them. Natural resources can only be analyzed and developed. The misunderstanding of this difference between things which man can produce and those resulting from nature's processes was clearly presented to me by a distinguished water supply engineer who, on a large international project, informed me quite strongly that the only new water source available contained too much iron and manganese for the system he had conceived. Therefore, he stated, the *source* could not be used. Needless to say, the design was later changed to remove the iron and manganese. To summarize this point, it is felt that those persons preparing water supply projects and contracts should be clearly aware of the totally different problems encountered in evaluation of natural resources, as opposed to water supply engineering.

Invalid assumptions regarding availability and/or importance of water sources for a system have many times resulted in project delays and costly redesign. A number of projects I have been active on have suffered from this difficulty. This problem is usually associated with a project scope of work which overlooks the system source or gives it only token attention. This, I am led to believe, can be traced to the education and experience of some water supply specialists. A few years ago I made a curosry study of several engineering school curriculum bulletins and was surprised to find the small number of courses offered in water resources evaluation of any kind. Additionally, most of the curricula offered no groundwater related courses at all. From the aspect of experience, it has become apparent that many of the people responsible for preparing project documents have worked in locations where large rivers or abundant groundwater are sources of system supply. For these individuals, a new water resource has meant only placing another intake pipeline in a surface stream or constructing another high capacity well. Because such bountiful resources exist in some areas, water source may not be considered to be a problem. As a consequence, little consideration may be given in the formulation of some projects to the possibility of limited or difficult water availability. This factor is usually corrected after the first problem project, but may be very expensive to both the professional and his client.

Limitations of water resources evaluations in unexplored or undeveloped areas offer significant challenges to those conducting studies for feasibility and design projects. Most frequently, little hard data or reliable information exists regarding such areas. Hydrologic and hydrogeologic conditions must generally be determined from brief field observations, and small amounts of information.

To meet project schedules. test and/or production programs must be conceptualized and conducted rapidly, with benefit of little or no knowledge of long term physical conditions. In many cases, these limitations result in gaps of information which are necessary for project continuation.

Again, the limitations of water resources evaluations should be recognized early on in feasibility/design projects to avoid unnecessary delays and expenditures.

Inadequate budgets both in time and funding for water resources determinations on projects are almost always the result of poor logic. Since I have been associated with several projects plagued by this problem, I believe I have analysed at least one cause of this poor logic. It involves budgeting a water supply project as if it were a sewerage project, which in theory should be exact opposites. This budgeting procedure results from poor judgement, lack of knowledge or both, and reasons as follows:

A. Costs of system are easily determined at the point of delivery, i.e., customer connections.
B. Area of service and distribution system can be easily defined and/or estimated.
C. Pumping and storage facilities costs can be generally estimated for the distribution system.
D. Treatment requirements can be given a worst case estimate based upon Items A, B and C design requirements.
E. Source transmission pipeline requirements for diameter and capacity are known from Items A, B, C, and D. Length is not known, so a large contingency factor is used.
F. Water source development cost cannot be determined or assumed. Location, type (surface, groundwater or composite), quantity, quality *not known.*

The prevailing recommendation may be: Proceed immediately with design of budgeted Items A, B, C, D and E. For Item F – hope for the best.

As can be noted, budgeting in this manner starts at the user with easily determined costs. Costs become increasingly difficult to estimate as they move in the direction of transmission pipeline and may be impossible to estimate for source. This approach, I contend, is tantamount to planning a sewage system without a point of discharge. Using the budgeting method above frequently provides adequate funding for the easily costed items, but very poor funding for the unknown new water source item. Contrary to the beliefs of some, water resources evaluations can be accomplished effectively and efficiently if proper timing and funding is provided. It is not, as many appear to think, a wasteful or delaving exercise. It is a necessary effort on the critical path of every water supply project.

To this point, I have first attempted to describe the problems or effects which can develop in feasibility design studies if difficulties arise with respect to new sources for planned projects.

Second, an attempt has been made to give some insight as to why water source problems may occur within the operational structure of feasibility study projects.

The third point I wish to express is a procedural recommendation which could assist in the orderly flow of projects to avoid wastes of time and funding. The approach recommended has evolved through several years within the Local Water Utilities Administration of the Republic of the Philippines. This approach may, in small part, has contributed to the model success of that organization.

Returning again to Table A, it appears logical that all chapters and items to be considered through Chapter V, Item 5.03 (Additional Sources of Supply) should be determined prior to any attempt to proceed to following items. This approach would avoid necessity for redesign, project cost estimating, detailed financial studies, etc., all costly but perhaps useless and misleading if the water source areas change or are found not to exist.

If a water source proves to be easily confirmed as both physically and financially feasible, a given project should proceed smoothly into design and, eventually construction. However, in the event the new supply source requires additional exploration and/or testing, feasibility and design efforts should be discontinued until the resource for the supply is determined to be available. Immediate action to confirm the resource should be instituted as this time. This is logical and also a simple concept, unfortunately Terms of Reference and Contracts for feasibility studies seldom make accommodation for questionable water sources, and it may not be known to a client that a problem exists until the total feasibility-master plan is completed. It is my contention that no water supply feasibility study or design should proceed on any project until the viability of the source is proven beyond doubt. The earlier in a project that the source condition is known, the better for all parties.

Procedurally the information of supply source can be easily provided for in contract documents prepared by a funding agency or client.

In summary, I have three procedural recommendations to make which, on the basis of my experience, could result in significant time and cost efficiencies during development of feasibility studies and design of water supply projects, specifically with respect to new water sources.

1. Water source studies should be initiated before or in the very earliest stages of every water supply feasibility project.

2. The water source determination should be placed directly on the critical path of each project and confirmation of source should be required before a project is allowed to continue.
3. Each water supply feasibility project should be provided a conditional contingency fund to be made available in the event additional source exploration and/or testing is required.

The latter recommendation would allow an easy transition to, for example, a test drilling program within the structure of the feasibility study, rather than a need for complete changes in project contracts, negotiations and the many costly and delaying activities that occur frequently in current feasibility programs.

I am confident that if these three recommendations are considered in the formulation of future water supply feasibility studies, such projects will proceed more efficiently and lead to more successful results.

TABLE A

Chapter **Title**

I Introduction
II Existing Water Supply System
III Socio-economic Conditions
IV Environmental Aspects
V Water System Master Plan
    5.01 General
    5.02 Water Requirements
        A. Population Served
        B. Summary of Water Demands
        C. Water Demand by Classification
        D. Residential Service Connections
        E. Commerical Establishments
        F. Hotels and Motels
        G. Civil and Military Facilities
        H. Schools
        I. Religious Institutions
        J. Factories
        K. Hospitals and Clinics
        L. Railway and Bus Stations
        M. Markets
        N. Public Bath Houses
        O. Leakage and Unaccounted Water
        P. Summary of Demands
    5.03 Additional Sources of Supply
        A. Area of Investigation
        B. Surface Hydrology
        C. General Geologic Features
        D. Comments on Existing Water Sources
        E. Water Resources Occurrence
        F. Water Quality Conditions
        G. Potential Additional Resources Development Development
        H. Conclusions
        I. Recommendations
    5.04 Master Plan Improvements
        A. Technological Aspects
        B. Design Criteria
        C. Major Facilities
    5.05 Implementation Schedule
    5.06 Cost Estimates
        A. Unit Cost
        B. Project Cost
VI Recommended Immediate Imrpovements
VII Financial Studies
    7.01 Funding Requirements
    7.02 Sources of Financing
    7.03 Financial Feasibility
    7.04 Water Rates
    7.05 Ability to Pay
VIII Organization and Administrative Procedures

TOWARDS REDUCING WATER SYSTEM DESIGN EFFORT

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The task of providing water to the people of Southeast Asia is taking on a new dimension. Most nations have concentrated their early efforts in the Capitol cities. The next order of priority was the outlaying urban centers. So far, so good. Conventional problems were met with conventional solutions.

Now that attention is being turned towards the smaller communities, a brand new obstacle has appeared. It is a far greater obstacle to water improvements than simple things like bacteria, distances, gravity and friction. The new obstacle is deceptively simple. It is numbers.

The problem used to be one of making safe water flow through pipes. The problem is now how to reduce the number of questions to be answered to a manageable proportion.

The Philippines is a case in point. The number of communities that can benefit from water systems is in the ten of thousands. With each one of those communities, the same questions exist that did in the larger cities. Questions such as:

Where are the various sources?
What is the quality of each?
Where are the people?
What is the proper level of service?
What is the terrain?

As we all know, behind each one of these questions lie several more which must first be answered.

Considering the distances and the incumbent problems of transportation and communication, the time investment in considering each aspect is at least doubled. A casual arithmetic exercise yields a time frame in the order of six man months to properly examine each community. This amount of time does not include actual design or construction effort.

It is at the design stage that one may legitimately question the value of highly accurate inputs. Most designs are based upon many assumptions which when combined will yield only an approximate result. If this is true, than where is the justification for highly accurate inputs?

Let us take a simple design exercise as an example.

The basic hypothesis will be that we will design a system that will provide safe water for a given community.

Question //1. Shall we protect the safety of the water by maintaining only a positive pressure at all points or some value such as 5 PSI or 10 PSI or 20 PSI?

Result: Widely varying designs.

Question //2. Which community shall I design for? The one that exists today or the one that I predict will exist 10 years from now, or 20 years or the one that somebody else predicts will exist 10 or 20 years from now?

Result: Widely varying designs.

Question //3. What is the expected peak flow rate for each tributary pipeline? If we don't know, shall we assume an arbitrary relationship between this value and average consumption? Is a single such relationship valid as the tributary number of users get smaller at the ends of the system? 160%, 180% or 200%.

Result: Widely varying designs.

Question //4. Shall we utilize plastic pipes with a "C" value of 150 or 130 or shall we use steel pipes with a value of 100 when new or 70 after corrosion?

Result: Widely varying designs.

Without belaboring the point further it can be seen that for any given community it is possible for several highly competent designers working independently to produce very different designs.

Regardless of which design is implemented there will come a time when the system will no longer be capable of performing its basic mission of providing safe water. It is this length of time which is the end variable in all of the possible combinations pointed out above.

If a design with a 20-year design life is too conservative, that life may actually be 25 years. If it is not conservative, it may be 10 years. Neither of these cases represent a disaster. It is the basic premise of this discussion that this discrepancy of time is acceptable if, in its acceptance, conditions prevail whereby more people are served safe water.

In short, perhaps there is an acceptable way to put less effort into design in order to put more effort into construction.

Several attempts are being made along this lines. An example is Indonesia. In that country, experimentation is being done on a "modular" approach. Packaged treatment plants are proposed that ignore the usual customized approach. One proposal is being considered that calls for distribution systems to consist of either 4" or 2" pipes on a formulated basis. This is yet to be fully developed but the direction and motivation for the effort is clear.

This discussion does not presume to set forth a proposition as one solution to the problem. Instead it is a plea that serious consideration be given to the concept.

Consider the possibility of having only one, or at the most, three proposed distribution system designs for any given type of community and all communities divided into say, four types. It would only remain for an investigator to correctly classify each community. This may appear to be an over-simplification of the problem, but then again maybe there should only be two types of communities.

Remember that a custom-tailored suit requires numerous measurements and several fittings while a ready-to-wear suit requires only the chest measurement and a decision as to whether the arms should be short, medium or long. The trade-off in this case is obvious but it is exactly the same trade-off that I feel the water industry must consider. It is the sacrificing of accuracy for the conservation of human resources. This will be all the more valid if it is accepted that a high level of accuracy did not really exist in the first place.

Opportunities abound for the development of such as concept. These tens of thousands of communities offer a perfect laboratory. Several candidate schemes could be attempted simultaneously. Proper instrumentation and monitoring will quickly determine actual performance for comparison to projections. The comparisons should include:

1. Input time required
2. Level of skills required
3. Hydraulic performance
4. Projected life expectancy
5. Economic costs

A very basic question exists which must be resolved before any meaningful work can be accomplished. That is, a clear understanding of consumption patterns in small systems must be gained.

For public standpost systems the peak flow rate will depend on the percentage of standposts which will be used simultaneously and the flow rate of each. As the ratio of population for standpost may be low in some systems this may not be 100%. But what is it? The same question of simultaneous useage exists in systems with direct household connections. Here we know the percentage is quite low. But how low? Consider the much used and abused value of 200% peaking factor for a city of one million. If you determine that the average daily consumption is actually 30 gallons per capita and there are an average six persons per connection which can flow fully at an average of 5 GPM, then 200% peak flow (41,667 GPM) means that the equivalent simultaneous useage is only 5%. In other words, only 5% of the connections are in use at any one time under maximum conditions.

For the large system we have been used to applying these relationships to, the average have the opportunity to operate. When the numbers become small, such as in small communities, these may be very much in error.

In a small community, many pipelines may have only five or say twenty connections. If three of the twenty users take water simultaneously, the peaking factor for that pipeline is 600% based upon the averages we discussed above. Obviously, if we use the old 200% value in this case, we will be in substantial error.

Insight into consumption patterns can be gained by monitoring established community water systems. It will also be enhanced by the data collected from the development efforts of a non-design (or pre-design) program. This is because, presumably, most early systems will be over-designed to some extent and to find true consumption pattern requirements, it will be necessary that the system being examined at least not be overloaded.

In summary, it is suggested that trial efforts be made to produce a methodology that will yield an economic trade-off of system life expectancy for human resources dedicated to design.

Before leaving this subject, it is important that we constantly remind ourselves that it is folly to place too much importance to these physical matters as compared to the institutional aspects. It will matter not at all if the system is overdesigned or underdesigned or precisely correct if, due to lack of funds or administrative capability, the system falls early into disuse.

PROGRAM CONCEPTS FOR LOW COST WATER SUPPLY PROJECTS

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INTRODUCTION

The provision of potable water throughout the country is a declared policy of the state. The attainment of the objective of complete water supply coverage requires a concerted effort on the part of both the government and the private sector due to magnitude of the problem. Data on the water supply coverage as of July 1980 shows that of the total population of the country, only 43% are served by public water supply facilities. In the urban areas, 66% are served by public water supply systems. In the rural areas where 70% of the total population live, only 33% of the population are served. Based on the population of 48 million in 1980 it can be seen that efforts of the government will be addressed to the 27 million Filipinos not adequately served by a water system. Of this number 23 million are in the rural areas.

Among the strategies of the government in its approach to the provision of adequate water supply the encouragement of self-help and self-reliant projects. Complementary to this is the adoption of levels of service that are best suited to the socio-economic condition in the project areas.

The government has defined basically three (3) levels of service for providing domestic water supply and these are:

Level I – Point Source:
a well or a spring serving about 50 households

Level II – Communal Faucets:
a system composed of a source, a piped distribution network and a faucet for every 4 to 6 households.

Level III – Individual Connections:
a system composed of a source, a piped distribution network and at least one faucet per households.

Each of these levels of service has technical, financial, and institutional implications that affect implementing institutions, the local governments, the designers, the contractors and, the benefitting communities.

Estimates show that for both the short term and long term needs of the rural areas some 100,000 shallow wells and 50,000 deep wells together with about 75,000 barangay communal faucet systems and 1,000 small Poblacion systems will have to be built over a period of 20 years up to year 2000 at an estimated cost of about P6 billion.

The concepts of how the massive program can be implemented and how it can be made to work in the rural areas must be analyzed in the light of previous efforts of the government in the development of the water supply sectors.

PREVIOUS EFFORTS IN THE PROVISION OF WATER SUPPLY

Until recently, efforts of the government were concentrated in the construction of artesian wells, the development of springs and waterworks systems which are essentially Levels I and III systems. There were about 30,000 wells and springs developed and about 1,500 waterworks systems constructed in the past. Many water facilities serving the population centers outside Manila were constructed before the Second World War. These systems have not coped up with the demands of a growing population and an expanding economy. Inadequate maintenance led to the deterioration of most systems resulting in inadequate supplies and unreliable service.

The conditions of many water supply facilities and the low level of coverage particularly in the rural areas can be attributed to institutional weaknesses, constraints in skilled manpower, equipment and financial resources and the application of inappropriate technologies and standards.

The maintenance program for the artesian wells was inadequate in terms of both manpower and budgetary requirements. Response to requests for repairs takes a long time leading to further deterioration before repairs can be made. Most waterworks systems are turned over to local governments upon completion of construction for operation and maintenance. Local government units, in general, do not have a personnel trained to efficiently manage the water utilities as well as technician to operate the facilities. In many cases, water rates were unrealistically low, thus, inadequate to finance the operation and maintenance of the systems.

Previous efforts in the provision of water supply were uncoordinated and were in the hands of various agencies leading to serious gaps and overlaps in the planning and programming of projects, especially, in the rural water supply sub-sector. The creation of the Metropolitan Waterworks and Sewerage System (MWSS) and the Local Water Utilities Administration (LWUA) during the first half of the last decade and that of the Rural Waterworks Development Corporation (RWDC) early 1980 rationalized the water supply sector by delineating the areas of jurisdiction of the three agencies. The MWSS is responsible for Metro-Manila and continguous areas defined in its charter, LWUA for cities and municipalities of 20,000 or more population and RWDC for areas not under MWSS and LWUA which are mostly small rural communities.

Both the MWSS and LWUA have established the technical models, criteria and standards, the level of service and the institutions that they are using in their areas of responsibility that are predominantly urban areas. In most rural communities, the sophistication of urban systems providing Level III service are beyond the manpower and financial capability of most rural communities. Level I and Level II projects can provide the need of the rural population.

MAIN CONSIDERATIONS IN PROVIDING WATER TO COMMUNITIES

Before any decision can be made on what level of service will be provided to a community, the technical, financial and institutional consideration must be analyzed and matched with the capabilities of the beneficiaries as well as those of the implementing local bodies.

With a point source or a Level I project where people are considered served if they are within 250 meters of a point source, the per capita daily demand is about 5-10 gallons. Bringing the water to within 25 meters with communal faucets could increase the daily demand to 10-20 gallons per capita. A faucet within the yard of a household may increase this to about 30 gpcd and to a higher value if connections are within the house. The greater amount of water delivered will mean greater per capita investment cost to the government.

A communal faucet system will most probably require a pump operator and a water fee collector. Operation and maintenance becomes more expensive, hence, higher water fees, and the technical skill required would be higher. The cost of development to the government per capita increases.

The Level III systems are the most expensive both to the government and to the users; management and operation are more complicated and highly trained technical operators are required.

Each level of service has a combination of financial, technological, manpower and institution requirements that must all be satisfied to be able to set up a system in a particular community.

TYPICAL LEVEL I AND LEVEL II PROJECTS

In most villages outside the town centers or poblacion, the clustering of houses are such that small independent systems serving a village or part of a village are more viable than a system each serving two or more villages. Level I and Level II projects serve on the average cluster sizes of 50 and 100 households, respectively.

As a matter of policy, the government will provide 90% of the cost of Level I projects as a grant. For Level II projects, 90% of the cost of constructing the facilities will be provided as a loan (maximum of 4% interest per annum, 20 years repayment period). In both cases, it is the responsibility of the community to provide the remaining 10% as their local equity. Sources of the local equity which can be in cash or in kind may be from resources of the users themselves or from funds allotted by the local governments for development projects in the villages.

An innovation from the previous practice of the government operating and maintaining the systems is the concept of the rural waterworks association (RWA) which is an association composed of user-households as members which shall be responsible for the operation and maintenance of the systems. The formation and registration of the RWA with RWDC is a pre-requisite to the construction of the community's water supply system. The philosophy behind the creation of the RWA is that a system managed and operated by the users themselves is more responsive to the needs of the community which with adequate training can lead to more efficient and more effective operations that are within the limits of the resources and capabilities of the community.

The description of the capacities and the requirements of typical Level I and Level II projects are given in outline form below.

A. Level Projects:

Projects under the Level I category can be classified into two, namely, shallow wells or deep wells.

1. Description:

   a) Shallow wells are wells fitted with a hand pump with an average of 80 feet of 1-½" diameter PVC or GI pipes, and PVC screens; water level is within 20 ft. of the ground level.

   b) Deep wells are wells fitted with a hand pump on an average of 200 feet of 4 in. diameter PVC or galvanized steel pipe casing with 1-½" diameter GI drop pipe and a deep-set cylinder where water levels are more than 20 ft. from the ground level.

2. Pumping Capacity	–	7-10 gpm
3. Average Cost	:	P 1,000 for shallow wells P10,000 for deep wells
4. Average Number of Ho Households Served	:	50
5. Institutional Requirement	:	Formation and registration of RWA
6. Operation and Maintenance	:	RWA
7. Manpower Requirement	:	Collector/Repairman (for minor repairs)
8. Funding	:	90% government grant; 10% local equity
9. Monthly water fee	:	P0.50-P1.00 per household for major repairs and replacement costs in the future.

B. Level II Projects

1. Description:

Level II systems are piped systems with several communal faucets serving 4 to 6 households each. The components of a typical system are the following:

   a) Point sources which is either a well or a spring producing at least 20 gpm
   b) An electric driven pump of about 1 to 2 HP
   c) A storage tank of about 2,000-4,000 gallons
   d) Distribution network of pipes including communal faucets

2. Average Cost	:	P60,000 – This represents the cost of upgrading deep wells to Level II.
3. Average Number of Households Served	:	100
4. Institutional Requirement	:	Formation and registration of RWA
5. Operation and Maintenance	:	RWA
6. Manpower Requirement	:	Operator and Collector
7. Funding	:	90% Soft Loan 10% Local equity
8. Loan Terms	:	Annual interest not exceeding 4% payable in 20 years
9. Monthly Water Fee	:	P6.00-P15.00 per household to cover the cost of operation, maintenance, salaries and amortization of the loan.

C. *Design Criteria*

An important factor in the design of water supply systems is the selection of appropriate design criteria. This becomes critical where cost considerations become primary factors in the selection of alternatives. In general, high standards and design criteria often result in more expensive systems. The design criteria being used for the Level II systems given below were based on critical analysis of the requirements of the rural communities.

1. Design Period	:	5 years
2. Population Growth Rate	:	3% per annum
3. Per Capita Consumption	:	60 lpcd (15 gpcd)
4. Households Served per Faucets	:	5-6 HH
5. Average Day Demand	:	Design Population x per Capita Consumption
6. Maximum Day Demand	:	1.3 x Average Day Demand
7. Maximum Hour Demand	:	2.5 x Average Day Demand
8. Pump Rate	:	Based on Maximum Day Demand
9. Storage Capacity	:	¼ of Average Day Demand
10. Pumping Hours	:	8-12 Hours
11. Minimum at the Faucets Pressure	:	5 psi

As in all standards, these figures are subject to review and revisions as more projects become operational and evaluations are made on their performance.

SELECTION OF ALTERNATIVES

Conditions in a particular community will determine the type of project that is appropriate and applicable to their needs. Among the factors and requirements to be considered are the following:

1. Availability of source(s) of water
2. Clustering of house
3. Availability of electricity
4. Willingness of potential users to form RWA's
5. Contribution of 10% local equity
6. Willingness and capacity to pay monthly water fee.

For ground water sources, the yield and depth of aquifers will determine whether shallow wells or deep wells will be constructed. Wells with adequate capacities and springs that are within one or two kilometers from the service area can be used for Level II projects.

Piped systems are viable for closely clustered households. A community of about 100 households within an area of half-kilometer radius can be served by a Level II system. For scattered households, point sources may be the alternative.

Level II projects require either a gravity source like an elevated spring or an electric driven pump, hence, the need for electricity.

The financial capability of the members of the community will determine their capacity to provide the 10% local equity and the monthly water fee. A Level I project will require about P100-P1,000 local equity and a monthly fee of P0.50 to P1.00. Level II projects on the average require about P6,000 worth of local equity and P6-P15 monthly water fee.

Of equal importance to these factors is the question of the community's willingness to form a rural waterworks association. The community will be responsible for the operation, maintenance and repair of the system once it is built. After a system has been turned over, its success and continued operation will depend on the community and no longer with the government.

PROJECT IMPLEMENTATION CONCEPTS

The undertaking of the Rural Water Supply Program on such a massive scale as mentioned in the introduction will require the efforts and participation of the national government and its agencies in the provinces, the local governments, the benefitting communities and the private sector. The general concept is that the government shall provide the technical, financial and institutional assistance to the communities through the RWA's.

The implementation of the program will be through cooperating agencies of the government particularly local government units through the waterworks committees and waterworks development task force on both the provincial and municipal levels. These particular impelmenting bodies will be strengthened in their project implementation capabilities through training on the technical and institutional aspects of project development.

The private sector particularly local engineering and construction firms may be involved in the bigger poblacion projects, in the construction of the systems including well drilling in areas where government capability is not sufficient to support the program.

The communities will have greater participation in the planning and decision-making concerning their water supply facilities. Their participation in construction may be in the provision of local labor, both unskilled or skilled, if available, as part of the local equity. Operation and maintenance is solely their responsibility. Again, the government will provide to the RWA's the needed training for the operation, maintenance and the management of the systems.

CONCLUSION

On the basis of the requirements of Level I and Level II projects, it can be seen that these two models can provide the water requirements of the rural communities. These projects have advantages over the more complicated Level III systems that are found in most urban centers.

The technical requirements and the size of the project make the development of projects simple enough that local engineers can easily be trained to prepare the design and feasibility studies and to supervise construction. Implementation for local government bodies is made less difficult.

The cost of developing these projects and the cost recovery scheme for Level II projects require less funding resource per household on the part of the government as compared to bigger systems. On the part of the users, the monthly fee is reasonable and within their paying capacity.

Manpower requirements to operate the systems can be obtained from the community itself if provided with adequate training which is also complicated. The systems being small, they are easier to manage and maintain.

With these two alternatives, all rural communities should be able to afford water supply systems of their own.

INSTITUTIONAL FRAMEWORK FOR RURAL WATER SUPPLY PROGRAMS

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INTRODUCTION: PROBLEM AND SITUATION

The policy objectives of the government of total water supply coverage for the whole country was declared against a backdrop situation that a large portion of our population does not have reasonable access to potable water – the basic amenity which cannot be done away with by any family. In the past decade the rural areas have at best 35% of its population served with water supply services. Of the 4.3 million rural households 70% do not have access to potable water. The figure could be higher if those inadequately served are taken into account. Roughly, this is a population of 20 million which increases by half a million annuallly.

This general situation tends to give rise to a number of problems which viewed from the socio-economic stand point of rural communities less favored with the minimum physical amenities accrue increasing acuteness with every solution delayed. Such problems are –

1. the increasing demand for potable water due to the increasing population and backlog of projects poses a difficulty of per capita share reduction of the rural water sector in the total public investments;
2. the increasing relatively high cost per capita investment of rural water supplies as compared with urban systems works in keener competition with other infrastructural sectors demanding their shares of the national budget allocation.
3. rate of morbidity and mortality due to water borne diseases is high among rural dwellers, especially in the coastal areas.

Viewed from another point, the situation may be seen as to have resulted from the commonly held observation that the problems of water supply of the rural areas are due to:

1. inadequate budgetary allocation for rural water supply services;
2. lack of trained manpower to provide direction, training, supervision and technical services and to motivate communities to participate in providing for themselves water supply services;
3. undeveloped community participation in developing waterworks systems;
4. inadequate operational and maintenance skills in managing the system;
5. weak development of organizational structures at the community level, as well as at the national and local levels.

It then appears that the major problems of the water supply situation of the rural areas are institutional and financial. This can be illustrated with the following observations:

1. The water supply systems in the rural areas, which are primarily hand pumps, suffered from lack of maintenance or utter neglect. One out of three pump wells is inoperational due to lack of maintenance or none at all. Why? The beneficiaries consider the project wholly a government responsibility to the people and with such perception they have hardly developed any maintenance responsibility for the project. It resulted also to the situation that many a system has not been effectively used vis-a-vis the life span of its material components thus cutting a heavy drain on the limited budgetary allocation of the water supply sector.
2. In the planning for the rural water sector more is to be desired even "with coordination being imposed at the highest levels through interlocking boards of directors/trustees, councils or personal channel of communication." This sad state leaves the so called "grey area" without an adequate program, compounding the situation by the fact that the line agencies do not have enough capa-

bility to provide the beneficiaries appropriate guidance on operation and maintenance due to financial constraint and inadequate trained personnel.[2]

The observations point directly to the need for an institutional framework which provides for an institutional framework which provides for development of capabilities to plan and implement a coordinated program on rural water supply. This is a tall order that requires a leadership that can inspire the rank and file of the sector and must have the support of the people.

LEADERSHIP AND POLICY

At present our national leadership addresses itself with more vigor and urgency to increasing the standard of living of the people, especially in the rural areas. Madame Governor Imelda Romualdez Marcos once said "Water is one basic need of every settlement. Let us make water the number one service to be delivered to the people." The First Lady's concern was based on the awareness that the absence of water or the lack of it is a major factor in holding back development, the improvement of the standard of living and the health of the people. Water is basic in life.

Before the turn of the seventies the government has placed an increasing emphasis on the prevention of this basic need. President Marcos rationalized the water supply sector and initiated a nationwide communal water pump program using latest available low-cost method. Early this year the Rural Waterworks Development Corporation (RWDC) was created and the rationalization of the water supply was further defined by assigning the Metropolitan Waterworks and Sewerage System (MWSS) to concentrate its operation in Metro Manila and contiguous areas added to its jurisdiction, the Local Water Utilities Administration (LWUA) to undertake water supply services in municipalities and cities with population of 20,000 or more and the RWDC to the areas not covered by the MWSS and the LWUA.

With the creation of the RWDC the structure is provided to be responsibile for the implementation of the basic policies on the government's efforts on water supply coverage of the rural areas. These policies are –

1. The encouragement of self-help and self-reliant water supply projects and the promotion of non-profit, non-stock rural waterworks associations (RWA's) that will own, construct, operate and maintain water supply systems;
2. That grants for point source development and loans for communal faucet and poblacion systems shall be provided up to 90% of the project cost and 10% shall be the minimum equity in cash or in kind of the beneficiaries; and
3. That local governments shall administer and coordinate the implementation of rural water supply projects in their respective areas.

These policies are significant for the rural water sector because they not only affect the quantitative aspect in terms of physical targets, but also the social and organizational arrangements of implementing structures in water supply, as well as the pivotal involvement of the local people who will themselves be beneficiary-owners of the project.

TARGETS AND OBJECTIVES

The Rural Water Supply Program aims to provide –

- all barangays with Level I service by 1981,
- all poblacions with at least Level II service by 1984, and all barangays, by 1990, and
- all poblacions with Level III service by the year 2000 and all sitios, a minimum of Level II service.

These require for a ten-year construction of the following targets:

Shallow Wells	100,000
Deep Wells	25,000
Barangay Communal Faucet Systems	30,250
Poblacion Systems	1,000

involving a funding requirement of some 3.7 billion pesos.

INSTITUTIONAL FRAMEWORK AND STRATEGIES

The charter of RWDC, Executive Order No. 577, provides the policy for the institutional framework of the water supply sector. The framework has provisions for direct participation of the community in project development, the local government to exercise initiative and build-up capabilities for rural waterworks program development and implementation and the development of the bases for coordination and mutually reinforcing relations among agencies undertaking projects in water supply and in the process enhance institutional growth at each level.

These provisions are specified in the following structures and strategies:

1. The National Water Resources Council shall be responsible for the scientific and orderly development and management of all water resources of the country, and formulation of policies and framework plans for water supply.

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[2]*NEDA, Water Supply Sanitation Components of Primary Health Care on the Philippines.* (undated)

World Health Organization and World Bank, *Report: Philippines Water Supply and Sewerage Sector Study,* vol. 1, 1977

2. The water supply sector is rationalized for the MWSS, LWUA and RWDC to operate in their respective area of operation.
3. All other agencies of the government may undertake rural water supply projects provided they are in accordance with the policies and guidelines of the RWDC.
4. The Ministry of Public Works and Highways shall be the principal engineering and construction agency of the RWDC.
5. The RWDC shall make full use of the regional, provincial, and/or local organizations of government agencies and other corporations as may be conducive to the attainment of the objective of Executive Order No. 577, and
6. RWA's shall own, construct, operate and maintain self-help and self-reliant water supply projects and shall be extended assistance to sustain self development.

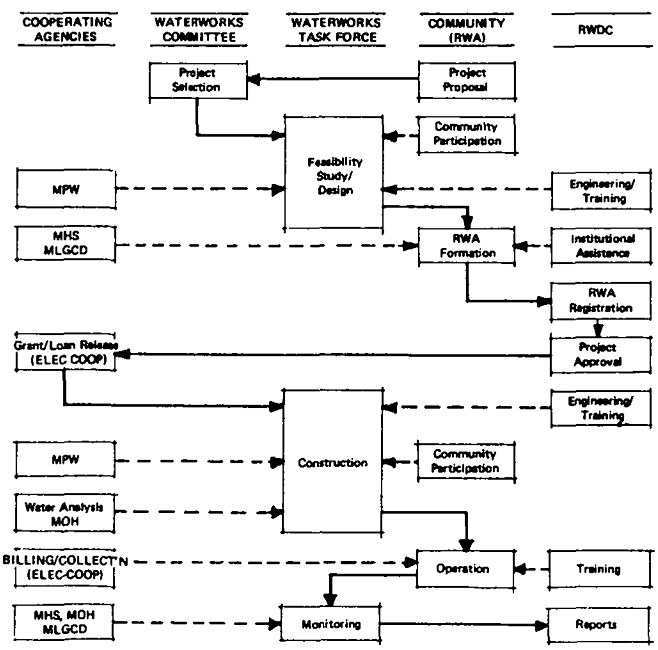
To establish the involvement of local governments in the program a memorandum of agreement is entered into by the RWDC with the provincial government. The agreement provides that the provincial government shall:

1. Organize and make functional the Provincial Waterworks Committee (PWC) which shall plan, program and implement the waterworks program of the province. The committee shall be under the chairmanship of the provincial governor and may have for its members from heads in the province of the following offices:
   a. Ministry of Public Works and Highways (MPWH)
   b. Ministry of Local Government and Community Development (MLGCD)
   c. Ministry of Health (MOH)
   d. Ministry of Human Settlement (MHS)
   e. Ministry of Education and Culture (MEC)
   f. Electric Cooperatives
   g. Kabataang Barangay
   h. Association of Barangay Councils
   i. League of Mayors
2. Organize the Provincial Waterworks Development Task Force (PWDTF), the staff arm of the PWC which shall prepare feasibility study and system design for Level II and III projects, assist in the organization of RWA's, undertake and supervise construction of waterworks projects. The task force shall be headed by a provincial waterworks officer assisted by an institutional and technical staff members which may be drawn and/or detailed from local or national government offices in the province.
3. Provide appropriate manpower, administrative and logistical support to the PWC and the PWDTF.

Working within this framework the RWDC adopts a scheme as a matter of general guideline for the local structures to assume a major role in implementing the rural waterworks program. The position held is that this strategy will help the local governments and communities develop capabilities for their development. The vast human resources, both trained and unskilled, are available for orientation and training to supply the manpower requirements of implementing the national rural water supply plan having that magnitude of total coverage for the rural areas. The national agencies concerned shall support and assist build up these local capabilities if we want to deliver and establish long lasting water supply services because there shall be local institutions that protect and maintain and expand the systems.

This position is embodied in the general guideline RWDC has adopted as in the following scheme;

PROJECT DEVELOPMENT



The implementing activities reflected in the chart are primarily the responsibilities of the local government and the community (RWA). The scheme shares the major responsibility to the local government and the community. They identify their own needs, plan and program the projects, construct and install them and operate and maintain the system. The community proposes a project request, organizes itself into a rural waterworks association, participates in project construction and operates and maintain the waterworks system. The local government through its waterworks committee and the waterworks development task force undertakes project selection, feasibility study and system design, construction of the system and monitors the project. On the other hand, the RWDC registers the RWA and provides it a grant or loan and training and technical assistance. Also technical and institutional assistance is extended by cooperating agencies like the MPWH, MHS, MLGCD, MOH and the electric cooperative.

The institutional framework of the rural water supply program therefore is one of small over-all structure helping and supporting a massive local structure of local governments and RWA's operating self-help and self-reliant water supply projects.

The RWDC is a small structure which is responsible for the formation and registration of RWA's that will construct, operate and maintain water supply systems in the rural areas. As the central structure for the subsector of rural water supply it provides the central role of planning, programming and funding the rural water supply programs of local governments. Provision of water supply services in the rural areas of LWUA and MWSS jurisdiction is the responsibility of these agencies, however funding for the projects shall be available by the RWDC and the generation of the projects shall be in accordance with the policies and guidelines of the RWDC. Other agencies of the government may undertake also rural water supply projects provided they too are in accordance with RWDC policies and guidelines.

The institutional framework provides participation of the community in the development of its water supply project, allows it to decide what level of service it will undertake and develops a stronger sense of responsibility in the members of the RWA because as owner-members they manage, operate and maintain the system.

The local government on its part is provided the opportunity to develop its capability to plan, program and implement its rural water supply program. With the assistance of RWDC and cooperating agencies local government personnel are provided training to develop and upgrade their skills to make them more efficient implementors.

At the national level, the composition of the board of directors of the RWDC ensures coordination and integration of rural water supply program for membership in the board includes the ministries and agencies involve in rural water supply.

DESIGN GUIDELINES FOR RURAL WATER SUPPLY

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1. Introduction

The selection of appropriate standards and design criteria for water supply systems for low income communities creates a difficult and important challenge for planners and designers of those systems. Water supply agencies can generally get by with applying standard rules of thumb and accepted practice for designing systems which serve the larger urban areas. Although overdesign is usually the result, because of large economies of scale in construction, per capita costs are relatively low, and the incomes of residents are generally sufficient to pay the required water rates.

The picture is quite different for low income urban communities. Here, the small size of the service population and the generally lower incomes mean that the community can ill afford the added costs resulting from application of conventional or overly conservative standards and criteria. For these areas, the challenge for planners and designers is to select standards and criteria such that the water system will perform effectively, provide an acceptable level of service, be affordable to the community and reduce costs as much as possible to allow limited budgets to be spread over the large number of communities in need of water supply systems. It is discouraging to note that planners and designers often make decisions regarding standards for service and design criteria with very little idea of how those decisions affect the costs of water supply systems.

Questions

We are all familiar with the questions that arise regarding what standards and criteria to use in system design. For instance, should public faucets be used as the standard of service in lieu of house connections or simple yard taps for low income urban and rural communities? How many person should share a public faucet? What per capita flow should be provided and what peaking factors should be used? What minimum system pressures and minimum pipe sizes should be allowed? If it is reasonable to expect that initial service will be upgraded in the near future, should the engineer design the initial facilities to satisfy the future expected demands or merely the initial demands, and how far into the future should the capacity of facilities be provided?

There are no set answers to any of the above questions. They will vary from country to country and within the same country. What engineer's need is better infromation on how decisions they do make regarding standards and criteria affect the system's cost and performance. With this data the engineer should be in a better position to establish rational standards and criteria.

Research

The World Bank has sponsored research over the past several years, which has been directed, at least in part, to investigating the above questions. This paper attempts to summarize some of the results of this work, and to suggest important considerations that planners and designers should consider in selecting standards of service and design criteria. The focus of the work presented in this paper is on the cost implications of decisions regarding standards and criteria. Little discussion is given here to other considerations such as political constraints, safety, reliability, and operation and maintenance which have been discussed in other manuals on rural water supply planning and design. In this paper, we define standard of service primarily as the level of convenience (e.g. type of connection such as public faucets and spacing of faucets, yard taps or house connections). Design criteria refer to other design variables which define the characteristics and perfromance of the system (e.g. per capita design flow, minimum residual pressures, design period, etc.).

2. Study Methods

The general approach adopted in this work was to prepare designs for water supply facilities for several low income communities located in different developing countries. In preparing designs, different standards of service and design criteria were selected. The characteristics and the costs of the resulting water supply facilities were then evaluated, a portion of which was done using linear regression analysis. The results and simple models developed from the analysis were used to demonstrate the sensitivity of system cost to varying standards and criteria, which in turn suggest what are the more important design considerations, which affect costs.

The specific study methodology included five major steps. (i) Select case studies, (ii) develop unit cost functions for different facilities, (iii) select service standards and design criteria, (iv) generate designs and (v) analyze the costs and characteristics of networks and other system components.

Study Areas

Case studies were selected in Brazil, Indonesia, Philippines, Upper Volta, and North Yeman all of which were sites of World Bank assisted projects. The cases included eight separate areas, low income communities within urban areas and separate rural communities. Field visits were made to five of the areas, while the others were studied with the use of detailed engineering, topographic, and socio-economic data obtained from reports and informal correspondence with responsible water supply agencies. Study areas varied in size from 5 to 185 hectares with population densities from 100 to 1000 persons per hectare.

Standards, Criteria and Designs

The next step involved selection of service standards and design criteria for water distribution networks and for other water supply components, followed by actual design of the facilities. Standards and criteria which were varied included the (i) type of distribution (e.g. through individual connections or public faucets), (ii) number of persons per public faucet, (iii) per capita flow, (iv) minimum pipe size (v) minimum residual pressure, and (vi) level of excess capacity or design period.

More than 100 different designs were prepared for the case study areas assuming a range of values for the standards and design criteria. In these designs, the number of persons per public faucet ranged from 90 to 2200. Per capita demand ranged from 20 liters per capita per day (lcd) to 100 lcd for service provided through public faucets, and from 50 lcd to 200 lcd for service provided through individual connections. For distribution system design, a ratio of peak hour to average flow of 3.0 was used. Maximum allowable headloss across networks was varied from 10 to 25 meters. Minimum pipe sizes used in designs ranged from 12 to 50 mm. For most designs, the design period was assumed to be 20 years, with service level remaining constant over this period.

For two study areas, initial service through public faucets was assumed to be upgraded to individual connections and to result in an increase in per capita consumption. Initial facilities (distribution networks, transmission line, treatment, storage and pumping) were sized in one case so as to satisfy only initial demands up to the time of service upgrading. At the time of upgrading, facility capacity was expanded to satisfy ultimate demand. For the other case, initial facilities were sized at the outset to satisfy the ultimate demand 20 years in the future associated with the upgraded service level. Cost were then compared to establish the most economical staging for each facility as well as difference in investment costs. Initial per capita consumption was taken to be 25 lcd. The per capita consumption for upgraded service was taken as 50, 100 and 200 lcd, and the time of upgrading was varied from 5 to 15 years after initial construction.

In all the cases, the designs of distribution networks were optimized using one of two computer programs, one applied to branched network design and the other to looped networks.

3. Results

Cost Functions

One of the first means the designer has in assessing the cost implications of decisions regarding design criteria and standards of service is to know something about the cost functions for the various water supply facilities that must be provided. In this work, cost functions were developed for water supply facilities, including treatment plants, storage tanks, ant pumping stations. Costs were found to be accurately represented by the following general expression:

$$C = KQ^a \qquad (1)$$

where C is construction costs, Q is facility capacity in units such as m^3 per day (cumd) or liters per second lps, and K and a are parameters. Regression analysis of data from several areas revealed that the value of "a" in equation 1 generally lies between 0.6 and 0.7 for treatment plants, pumping facilities* and storage reservoirs. These values indicate that these facilities exhibit economies of scale in construction. That is, average costs (cost/unit capa-

*Pumping facilities can also be represented by $C = KQ^a\ TDH^b$ where TDH is total dynamic head. The value of a in the expression was also between 0.6 and 0.7. The value of b ranged from 0.2-0.3.

city) decrease as the size of the facility increases. For instance, using a = 0.6 in equation (1), a doubling of capacity, Q, results in an increase in cost of only about 1.5 times. For central or upstream facilities (upstream of distribution) the consumption level is the design standard which is likely to affect cost most significantly. Simply by knowing the value of "a" in expression (1) for any facility, the designer can quickly assess the increase in cost, say from a baseline minimum service standard of public faucets providing 25 lcd to simple house connection service providing 75 lcd.

Using the above example for illustration, we assume "a" = 0.6. A three-fold increase in required flow would amount to an increase in cost for that particular facility of 1.9 times (i.e. $75/25)^{0.6}$ 1.9) or nearly double the cost of service through public faucets. With this information for each of the system components, the designer is in a position to make a judgement whether the added costs are affordable or desirable. The need is obvious to develop cost functions appropriate to each country and for different water supply facilities, in order to make accurate assessments of cost sensitivity.

This type of simple analysis is necessarily limited those facilities which can be represented by a single cost function. The analysis of the distribution networks, which for rural systems can account for 50% of more of total costs, is more complicated since the distribution system is made up of numerous interlinked components. Considerable effort was made in this study to analyze network characteristics and costs resulting from designs prepared for the case studies.

Distribution Networks

The objective of this portion of the work was to develop some general expressions for the characteristics and costs of distribution networks as a function of service standards and design criteria. These expressions, in turn, can be used to show the sensitivity of characteristics and costs to changing design assumptions. Since network costs are a function of both the size and length of pipelines, a general expression describing those costs is necessarily more complicated than expression (1). First, the length of network pipelines is likely to be a function service area size and for public faucet service, the distribution of faucets. The size of pipelines, on the other hand, is a function of available head and flow distribution as well as total flow. Developing a general network cost expression first required establishing the effect of these design standards and criteria on the length and size of pipelines.

Linear regression analysis was used to analyze both network pipe length and size. From the analysis the most appropriate expression which describes the length of a branched network was found to be:

$$L/P = 82\,(P/A)^{-0.49}\,(P/N)^{-0.55} \qquad (2)$$

where L/P = pipe length (m) per capita, P/A = population density in persons per hectare and P/N = persons per public faucet. Equation 2 says that the length of pipeline per capita is a function of population density and the number of persons per public faucet. For instance, assume a hypothetical community of 6000 persons has a P/A = 200 persons per hectare, and that a minimum acceptable service level provides 200 persons per faucet (33 households/faucet @ 6 persons per house)*. From equation 2, the length of pipeline required per capita is 0.33 meters or a total of 1980 meters.

We can use this expression to show the effect of increasing convenience (i.e. service standard). For instance increasing service to 1 faucet for every 50 persons (3 households/faucet), will increase required pipe length to about 0.71 meters/person or to approximately 4260 meters, more than double the length required with the minimum acceptable standard. It should be noted that the above expression applies to rather compact communities, and may not be appropriate for communities which are spread along a single root (lineal).

In addition to pipe length, network designs were analyzed to determine pipe diameters. For each design, the average diameter of pipe (D) was calculated. Regression analysis was used to relate D to design criteria, service standard, and characteristics of the service area. Average network diameter does not have hydraulic meaning, but can be used to represent relative differences in network pipeline requirements. The most descriptive of the equations developed was:

$$D = 2.57\,N^{-0.17}\,P^{0.23}\,A^{0.10}\,(FQ/P)^{0.38}\,H^{-0.23} \qquad (3)$$

where N = Number of public faucets, P = design population, A = service area (ha) F = peaking factor (ratio of peak to average flow), Q = per capita demand (lcd), P = population and H = maximum allowable headloss across the network in meters. Assume that the population is fixed at 6000 for a hypothetical community in an area of 48 hectares. Equation 4 reduces to:

$$D = 26.4\,N^{-0.17}\,(FQ/P)^{0.38}H^{-0.23} \qquad (4)$$

where N, FQ/P and H are the design variables over which the engineer has control. From the above expression, D is seen to be relatively insensitive to both N and H. For instance, for a change of N from 120 to 60 public faucets (i.e. change from 100 persons to 50 persons per faucet), D increases by only 12.5%. Likewise, a doubling of allowable

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*WHO has recommended a minimum standard for public faucet service of 100 persons per faucet.

headloss across the network (equivalent to either raising input pressure or lowering minimum residual pressure at demand points) would result in a decrease in D of only about 15%. Holding N and H constant, a doubling of per capita flow, Q/P, will result in about a 30% increase in D, indicating that D is relatively more sensitive to changes in design flow than to either H or N. It is interesting to note that the exponents of FQ/P and H in expressions 3 and 4 are identical to those found in the Hazen-Williams equations which describes the hydraulic characteristics of a single pipeline.

The relative insensitivity of D to changing allowable headloss suggest that required pipesizes will be reduced only slightly by lowering minimum residual pressures say from 10 to 5 meters at demand points. Therefore, making small changes in residual pressure standards will not likely have a great effect on overall network costs.

A simple but still an accurate expression for D was found to be:

$$D = 2.93\ (P/N)^{0.21}\ (FQ/P)^{0.39} \qquad (5)$$

where each of the terms in equation 5 have been defined.

This expression says that average diameter of network pipeline is a function of the number of persons per public faucet and the per capita flow. Now that we have expressions for length and average diameter, we need a general cost expression. Although cost functions for distribution pipelines varied from country to country, the following equation was found to be fairly typical:

$$C/L = 0.03\ D^{1.4} \qquad (6)$$

where C/L = cost per unit length of pipelines ($/meter) and D = diameter (mm). If we substitute the right hand sides of (2) and (5) into equation (6) the following equation results:

$$C/P = 11.1\ (P/N)^{-0.26}\ (FQ/P)^{0.55}\ (P/A)^{-0.49} \qquad (7)$$

This equation represents the approximate per capita cost of a water distribution network as a function of persons per public faucet (P/N), peak per capita demand (FQ/P), and population density (P/A). The designer is primarily concerned with the first two variables in this equation, P/N and FQ/P, since these are variables over which he has control. Population density, on the other hand is defined by the characteristics of the community. The exponents of equation 7 are of particular importance. They represent the percentage change in per capita pipe costs per percent change in the variable to which they are attached.

Equation 7, therefore, is seen to be useful for estimating the sensitivity of total network cost to changes in the variables which define the standard of service. It can be used with different values of P/N to determine the change in cost relative to bringing water closer to the consumers. For instance, assume a population density of 200 persons per hectare and a per capita flow of 25 lcd with a peaking factor of 2.0. A decrease in the number of persons per standpost from 200 to 50 will change network pipe cost from 1.8/capita to about 2.6/capita or an increase of about 44%. Of course, cost would also increase due to the larger number of public faucets required. For instance, the number of public faucets for our community of 6000 would quadruple from 30 to 120, thereby increasing public faucet costs by a factor of 4. If is quite obvious that even after the basic decision to provide service through public faucets, has been made the designer can still affect costs significantly through the selection of the number of persons to service per faucet.

If we assume that this same equation applies roughly to networks that provide house connections, it can be used with different values of FQ/P to determine the sensitivity of cost to say using yard taps at 50 lcd, single housetaps (100 lcd) or full house plumbing (200 lcd). For instance, per capita cost would increase from $6.5/capita to about $14/capita as average per capita flow is increase from 50 to 200 led, or greater than a doubling of cost (assumes P/N = 6 and P/A = 200). From these figure, we see that cost are relatively more sensitive to changing per capita consumption than to adjusting public faucet spacing.

In most designs for water supply, engineers have opted for public storage rather than individual storage at the household. Recently, however, pilot projects have been initiated in the Philippines using inexpensive private storage tanks and flow restrictors at each household. With this type of design the distribution network pipelines can be sized for average rather than peak hourly demand, since the peak demand is meet by the individual storage tank, not by the distribution lines. Equation 7 suggest that network cost will decrease by about 32% as the peak factor, F, is reduced from 2 to 1. For larger peak factors associated with small communities, on the order of 2.5 – 5.0, the savings would be proportionately larger if these factors could be reduced to one. For instance, a reduction of F from 4 to 1 would cut network costs in half. Of course the designer must weigh these savings against the added cost, if any, of private storage vs. public storage.

One further question investigated concerned the effect on cost of using different minimum size pipelines in distribution networks. The advantages of using larger minimum size pipes (50-100 mm) are (1) to increase system reliability by decreasing the pressure on piepline walls, thus reducing frequency of breakage, and (2) to avoid having to strengthen or replace small diameter pipe as demands increase over time. The disadvantage of course is that larger minimum size pipes imply larger costs.

The results of designs prepared in this study are quite interesting. They show that in most designs which provide branching networks and public faucets, a significant proportion of pipeline can be as small as 25 mm and the system will still deliver water to consumers at acceptable pressures under peak flow conditions (Fire demands were not considered). To estimate actual network costs for one study community, the cost function $C/L = 0.03\ D^{1.4}$ was applied for pipes ranging in size from 25 to 100 mm. In this community of 6000, a branched network with 27 public faucets, each with a 100 meter service radius, was provided. The first design allowed 25 mm diameter pipe as the minimum. In the optional design of this network, sixty-five percent (65%) of the pipe in the network had diameter of less than 50mm, and the cost of the network amounted to $4.9 per capita. The same network designed with a minimum diameter of 50 mm cost $7.1/capita, representing an increase of nearly 58%. The above results are very sensitive to cost differences among the pipelines in the diameter range 25-50 mm, where very little cost data is currently available. It is evident from these results, however, that an arbitrary decision to set minimum pipe sizes at 50 mm or even larger, as is the practice in many countries, may result in an unnecessary and significant increase in the cost of the distribution network.

Design Capacity

This research addressed an additional question of concern to planners and designers. That is how much capacity should be provided in initial water supply facilities when the level of service is expected to be upgraded over time. Let's first look at the results of comparing numerous alternative capacity designs for the complex case of a distribution network, where service is upgraded from public faucet service to individual connections. The first option open to the designer as described under study methods, is to design the initial network to satisfy only demands up to the time of service upgrading, and then to expand capacity of the network by laying parallel lines where necessary when service is upgraded and per capita demand increases. The other option is to size the pipelines in the initial network, at the outset, to carry flows associated with the ultimate (upgraded) service level. When service is upgraded, therefore, initial pipelines will not require further strengthening.

The results of economic cost comparisons are interesting. They show that the most economical design approach is sensitive to the discount rate, the level of change in per capita demand as service is upgraded and to the time that service is upgraded. Considering prevailing discount rates in most developing countries, this analysis indicates that under most conditions of upgrading (i.e. an increase in per capita consumption of 3 times or more as service is upgraded and a delay in service upgrading greater than 5 years), capacity of pipelines should be sized only to carry flow associated with the initial service. Expansion of capacity should then be made when service is upgraded. If, however, service is expected to be upgraded within 5 years or less, then it may prove more economical to size and initial pipelines to carry the expected demands associated with the upgraded service level. These finding are contrary to design guidelines suggested recently the World Bank engineers as well as others. They have been advocating oversizing pipelines in the initial network which provides a low service level (public faucets) in anticipation that within 10 to 20 years service might be upgraded to individual connections providing 100-200 lcd.

Equation 7 can be used show the cost implication of following the latter suggestion. For instance, designing a public faucet network at Q/P = 25 lcd, F = 2, P/A = 200 and P/N = 50 was shown to cost about $7.1/capita. If the ultimate expected per capita demand 20 years in the future is 150 lcd (service through house connections), again with F = 2, the cost of designing the initial network to meet this demand would be about $19.1/capita, an increase of more than 2½ times. These calculations don't take into account population growth over the 20 years period which would add even more to the cost of this alternative. Even if initial overdesign is justifiable economically, it is likely that financial constraints may be binding in many cases, as suggested by these rough calculations.

SUMMARY

In summary, it should be emphasized that the equations presented in this paper are highly generalized, resulting from the analysis of designs prepared from communities with widely varying characteristics. The expressions should be used with caution in attempting to predict actual costs and system characteristics. However, it is likely that the expressions will be quite accurate in estimating the expected percentage change in cost and system characteristics resulting from changing standards and criteria. In the future, it may prove extremely valuable to develop similar expressions for individual countries, in which case estimates of costs could be more accurate and serve as a useful planning tool. A potential use of such expressions could be to aid in selecting uniform standards that may be applied to similar types of communities within the same country. At the very least they can give decision makers a better idea of the cost implications of the decisions that they do eventually make.

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NOTE: A number of papers and reports have been produced by the World Bank which provide a detailed reporting of the results presented in this paper and are listed under references. These materials are available from the World Bank from Mr. John Kalbameten, Senior Advisor, TWT, World Bank, 1818 H. Street, N.W. Washington D.C. 20433, USA.

METERISATION IN DEVELOPING COUNTRIES FOR URBAN RURAL TOWNS

by S.S. PATWARDHAN India

INTRODUCTION

In developing countries where new water supply projects are being taken on a large scale, water supply through meters is a prime necessity. Number of advantages are claimed due to metering. In this paper advantages and disadvantages of water supply through meters have been focussed. The observations are based on the actual data collected in the field on the urban water supply scheme where metering has been introduced in an existing water supply system.

DETAILS OF THE PROJECT

With a view to study in details the advantages of metered supply it was proposed to introduce metering in an existing water supply scheme in Pusad town of Yavatmal District. The Town has a population of 27960 (as per 1971 census). A water supply scheme was executed by Maharashtra Government in 1968. The estimated cost of the scheme was US$ 2 lakhs and the designed supply was 2 MLD for an anticipated population of 30,000 souls in 1990. The present population has already exceeded this figure. The advantage water consumption was 3 to 3.4 mld. in the year 1979. The scheme, though owned by Pusad Municipal Council, is maintained by the State Government on behalf of the Council and the maintenance charges are paid by the Municipal Committee to the Government.

REASONS FOR INTRODUCING METERING

In Yavatmal District three water works are maintained by the State Government and the per capita supplies of these towns during the year 1978 were as follows:

		Per capita supply
1. Yavatmal	(Pop. 65000)	68 Litres.
2. Pusad.	(Pop. 27960)	125 Litres.
3. Wani.	(Pop. 24455)	70 Litres.

It is observed from the above data that the per capita supply of Pusad town was more than that of Yavatmal town. However, Yavatmal town is being served with filtered water supply for the last 7 years. It is metered and is continuous. The water supplies at Pusad and Wani are intermittent and are restricted to 5 hours in the morning and 2 hours in the evening. Though the per capita supply at Pusad was more than that of Yavatmal town (where the supply is continuous) there were many complaints about inadequate pressures and insufficient quantity of water, particularly in high level areas.

It was, therefore, thought by the author that if the town would be supplied with metered water, the per capita consumption would be reduced, pressures on the distribution system would be increased and continuous and sufficient water supply could be maintained.

THE PROJECT

Since Pusad Water Supply Scheme belongs to Pusad Municipal Council, the financial investment for metering was to be done by the Municipal Council itself. No grant-in-aid from the State Government for such projects is admissible. It was, therefore, decided to approach the Municipal and request them to undertake the project of metering. An estimate of US 50,000 dollars for the project was prepared for providing and installing the following numbers of meters.

i)	15 mm	1950 Nos.
ii)	20 mm	25 Nos.
iii)	25 mm	25 Nos.

With a view to convince the Municipal Council a meeting of councilors was held at Pusad on 4.8.79 and all the pros and cons of the project were discussed. A number of doubts about the availability of continuous supply, improvement in pressures, etc. were raised, for which an assurance was given that after metering, continuous water supply would be maintained with adequate pressures. The Municipal Council was advised to collect a deposit of US 18 dollars per connection from the consumers. The amount of US 50,000 dollars was paid by the Municipal council in two instalments.

The first difficulty experienced in the above project was that of procurement of the meters. It was decided that all meters should be of one make only. An order was, therefore, placed on a supplier whose meters are available at Govt. approved rates. After continuous efforts and correspondence it was possible to procure the meters in two instalments and the work of fixing of meters was started in April 79. Before fixing of meters, regular observation on pressures in the distribution system at various points in the town were made. Observations for several months before metering were also made on daily demand, peak demand and daily fluctuations in demand. Daily peak factors and average monthly peak factors have been observed.

Results of the data about six months before and after metering have been studied and the observations are discussed further.

The project of fixing the water meters was completed in a period of about five months; 24 hours water supply through the meters was started from 10.10.79.

REACTIONS OF CONSUMERS

From a consumer's point of view two things are very much important. Consumer expectations are very limited. They feel that not much attention is paid by the Engineers to their demands.

The main expectations are:

1. The water supply should be adequate.
2. The pressure at the consumers tap should be sufficient.

In addition to above the other expectations are:

3. The water should be fairly clean and should not have any smell.
4. The water charges to be paid by them should be moderate.

The consumers of Pusad town expressed great satisfaction on completion of the Project since they noted the following advantages.

a) The water supply at their taps was for 24 hours as against very few hours in the morning and evening. Even during the days of hot summer where the temperature reaches at 46° C. in summer the water supply was continuous.

b) The pressures at their taps have increased beyond their expectations. This was quite a surprise to them since for the past eleven years they have never experienced, and never expected, such high pressures at their taps. This was particularly true for persons residing in high level zones, who had to fix the water top in specially prepared pits to increase the output from tap, and now they get water with full pressure not only at their usual taps but also at their bath rooms, etc. located on the first floors. (The town has only two storeyed buildings).

c) The quality of water remained unchanged and clean since there was no change in the treatment plant.

d) As regards the bills for the water supplied the first few months, the reaction was a harsh one since there was a considerable increase in the monthly expenditures. This made them to get the taps repaired to avoid unnecessary wastages.

TECHNICAL ADVANTAGES

i) Improvements in the Peak Factors:

As stated above the observations on hourly demand were made over a long period prior to metering and also after the project was completed. The peak factor in the month of March 79 which used to be 6.9 was reduced to about 2.9 in March 1980, i.e. after metering. The graphs showing the peak factors during January to March 1979, i.e. prior to metering and during January to March 1980, i.e. after metering are reproduced here. The graphs clearly indicate the reduction in the peak factors (Figs. I to 3).

The reasons for the reduction in peak factor are as follows:

a) In intermittent system the water is drawn by all the consumers during the limited time of supply, since the consumers have no alternative but to collect all the supply that comes from the tap. However in continuous supply everybody is free to draw the supply according to his requirements and according to his convenience. Therefore the possibility of all persons drawing the whole day's supply during a specific time is reduced.

The peak demand is usually between 7 to 9 hours.

ii) Capacities of Elevated Service Reservoirs. (E.S.R.)

The capacities of service reservoirs play a very important role in the smooth functioning of the distribution system.

Capacities of storages reservoirs depend upon the rate of hours of pumping and also on the hours of supply.

A typical mass curve for the water supply to the town of Pusad before metering has been plotted in Fig. 4. For working out the cumulative demand the peak factors are based on the actual observations made on the supply for the month of March 1979. The cumulative pumping was also plotted on the same graph. It will be seen from the graph that the total daily supply during the month of March was 34 lakhs litres per day and for this supply the net capacity of E.S.R. works out to 14.46 say 14.50 lakhs litres (approx. 48.5% of the supply).

After completion of the project the revised mass curve based on the actual peak factors was plotted (Fig. 4). It will be seen from the graph that the capacity of the E.S.R. works out to be 8.78 lakh litres for the same quantum of water supply, i.e. 34 lakh litres. The E.S.R. capacities required after metering are equivalent to about 25% of daily supply, i.e. practically 50% of the corresponding capacities required for running on intermittent supply.

iii) Improvements in the pressures in the Distribution system:

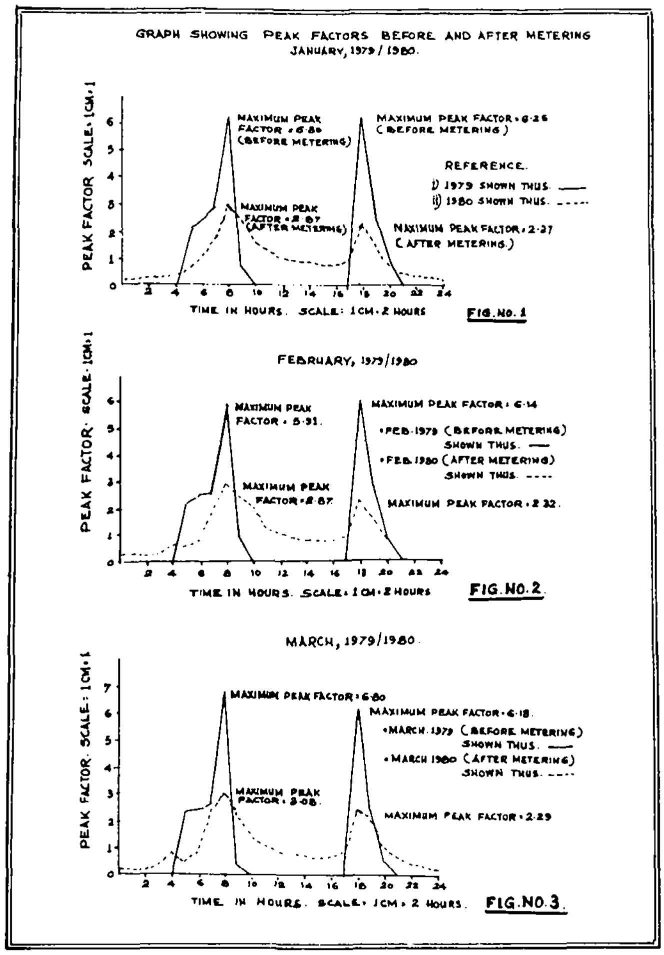
To study the effects on the pressures in the distribution system, pressures on the various lines were observed in the month of April 1979, i.e. before metering. Observations of pressures at 135 places were taken so as to cover the whole area of the town.

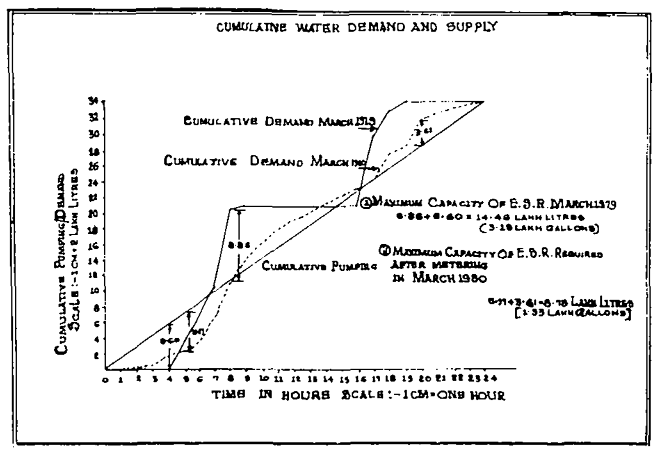
The pressures have improved from zero at some points to as high as 11.20 m. The analysis of the above 135 pressure observation are as follows:

Range of pressures. Pounds per sq. inch.	Equivalent Head in meters.	Before metering No. of observations falling in the specified range.	After metering No. of observations falling in the specified range.
1	2	3	4
0 – 0	0.	5.	Nil
1 to 5	0.7 to 3.5	71.	Nil
6 to 10	4.2 to 7	29.	Nil
11 to 15	7.7 to 10.50	5.	Nil
16 to 20	11.20 to 14	19.	16.
21 to 25	14.7 to 17.5	3.	26.
26 to 30	18.2 to 21.	3.	36.
31 to 35	21.7 to 24.5	Nil	39.
36 to 40	25.2 to 28	Nil	18.
	Total observation.	135	135.

The above analysis of the data clearly indicates that the minimum pressure anywhere in the distribution system was 11.20 meters as against 0 to 1 meter before metering. Prior to meter fixation about 105 consumers out of 135 i.e. 77% of the population used to get water with pressure less than 7 meters and after metering 100% of the population has got water with pressures more than 11.20 meters.

The reason for increase in pressures is mainly attributed to the reduction in the peak factors. A detailed analysis of flow through pipes, the frictional losses, etc. can be made, but in short it can be stated that the peak factors have been brought down from 6.8 in April 1979 to about 3.08 in March 1980. Therefore the velocities in the pipe lines were reduced in the ratio of peak factors i.e. say by 1/3 resulting in reducing the frictional losses and consequently increasing the pressures in the distribution system.





iv. Reduction in Wastage of Water:

One of the advantages claimed in the metering system is that there is a considerable reduction in water consumption due to reduction of wasteges. No doubt now-a-days one does not find any tap flowing uncontrolled and unattended in Pusad Town. However the experience does not indicate any appreciable reduction in the total water consumption. It can be argued that the wastage of water might have been properly utilized and paid for. The general tendency of the public is to use water adequately and they do not mind paying for the extra use they make.

On an average the bill per family is about US one to two dollars per month and no considerable saving can be expected by the consumers by curtailing the use of water. By using the water a little more lavishly the bill may go to about US 2.5 to 3 dollars per month which is not felt mcuh in these days.

A typical analysis of monthly bills is as follows:

Category. 1			No. of consumpers. 2	Percentage as compared with total consumers. 3	Cumulative percentage. 4
1.	Below u.s.	$1.20	755	36.4	36.40
2.	Between u.s.	$1.20 to 1.80	474	22.80	59.20
3.	Between u.s.	1.80 to 2.60	181	8.70	67.90
4.	Between u.s.	2.60 to 3.20	193	9.30	77.20
5.	Between u.s.	3.20 to 3.80	109	5.30	82.50
6.	Between u.s.	3.80 to 4.40	45	2.2	84.70
7.	Between u.s.	4.40 to 5.00	69	3.3	88.00
8.	Above u.s.	$5.00	250	12.00	100.00

It will be seen that about 60% of the population has to pay a bill of less than US 2 dollars per month.

v) Prevention of Water Pollution:

Since the pipe lines are full all the time the possibilities of pollution due to leaking joints and suction effects get reduced. However no studies have been made on this.

ECONOMICS OF THE PROJECT

i) Fixing of water rates:

For fixing of water rates no detailed study of economics was made. The rate was based on the present day maintenance and repairs (M and R) costs. The M and R cost expected was about U.S. 35,000 dollars per year. The present population is about 30,000 and the rate of supply assumed was 70 litres per capita per day. Therefore the total yearly supply works out to

$$\frac{70 \times 30000 \times 365}{10} = 766.50 \text{ million litres.}$$

Assuming a rate of U.S. 0.70 dollars per 10000 litres and 20% wastage, the expected revenue works out to

$$\frac{766.50 \times 106 \times 0.70 \times 0.80}{10000}$$

$= 42925$ U.S. dollars.

If the consumption is increased, the revenue will also be increased.

The present taxation system of the municipal committee is based on size of connection. The water taxes before metering were as follows: –

Dia. of connection.	Domestic use. per year	Other than Domestic use. per year
15 mm (1/2").	U.S. $ 11.00	U.S. $ 32
20 mm (3/4").	U.S. $ 22.00	U.S. $ 62
25 mm (1").	U.S. $ 33.00	U.S. $ 95

There was no general water cess.

The revenue assessed during the last three years and the expenditure on M. & R for the same period are as follows: –

Year.	Revenue Assessed.	Expenditure on M & R.
1976-77	U.S. $ 20000	U.S. $ 21000
1977-78	– do –	U.S. $ 30000
1978-79	– do –	U.S. $ 32000

The expenditure figures shown above are on the actual M & R figures and they do not take into consideration the depreciation charges, sinking funds etc.

For financing the cost of the metering project, the Municipal Council collected a deposit of U.S. $ 18 per consumer. Thus the Municipal Committee could collect about 2000 x 18 = 36,000 U.S. $. The remaining amoutn of 14,000 U.S. $ was financed by the Municipal Council from its own funds.

ii) Additional Burden due to Metering:

The Municipal Council had to employ the following additional staff due to metering system.

		Ad. Pay P.M.	Total per year.
1.	Billing Clerk – 2 Nos.	U.S. $ 50	U.S. $ 1200
2.	Meter Reader – 2 Nos.	U.S. $ 50	U.S. $ 1200
		Total	U.S. $ 2400

Thus the Municipal Council has to incur an additional expenditure of U.S.$ 2400 due to metering. It is expected that the council might have to spend an additional thousand U.S. dollars on the establishment to have adequate control.

In addition to above the expenditure required is on maintenance of meters. Normally about 10% to 15% meters go out of order and the repair charges per meter would be U.S. $ 3 to 4. Thus the increase in the mter repair charges would be 2000 x 0.15 x 3 = 900 U.S.$ per year.

Thus approximate additional burden due to metering would be U.S. 3500 dollars.

Thus the total expenditure on the maintenance and repair of the water supply after metering would go to U.S. $ 32000 + 3500 = 35500 U.S. dollars per year.

The bills of water supply are being collected by the Municipal Council directly from the consumers. On an average the revenue earned during the year by the Municipal Council is about 40000 U.S. dollars per year against the maintenance charges of 32000 U.S. dollars per year. Thus the Scheme was found financially beneficial to the Municipal Council.

Thus the Municipal Council expected to earn at least U.S. $ 8000 more than the actual expenditure on maintenance and repairs of the water supply scheme per year.

Before metering as stated above the revenue was fixed at u.s. $ 20,000 per year. As against this the Municipal Council would get u.s. $ 40,000 thus the increase in the revenue would be u.s. $ 20,000 per year which will easily cover the additional investments made in the metering project and can undertake further development works.

PRECAUTIONS IN OPERATIONS AND MAINTENANCE OF METERING SYSTEM.

The metering system has a few disadvantages, which need to be noted.

i) Accounting system and vigilance:

Metering system requires trained persons who should take meter readings promptly and prepare and distribute the bills quickly. A close watch on their work is very essential.

The system also requires maintenance of ledgers, working out arrears, connections and disconnections etc. All these works require prompt attention.

ii) Another drawback noticed is the maintenance of meters. Many of the meters are damaged by consumers and the administration should be strong enough to undertake prompt action against such persons.

Many meters go out of order and therefore a repair work shop has to be set up for carrying out repairs of the meters. Planning for procurement of the spares well in time, is also an essential part in the administration. For Pusad Project, this responsibility has been taken by this Division and the persons were trained for repair works at Yavatmal.

It is also observed that due to use of bleaching powder for chlorination the powder gets deposited in the meter and the meter get chocked. Use of liquid chlorine is therefore recommended where metering is to be introduced.

A programme regular servicing of meters is very essential. It is, therefore, suggested that every meter, after a period of two years should be removed, brought to the workshop, serviced and checked for accuracy. It should then be refitted.

CONCLUSIONS

From the above case study it can be concluded that metering Project has specific advantages in the functioning of distribution system; with adequate pressures, the consumers are kept satisfied. It also increases the revenue of the Municipal Committees so that the water supply schemes can be self-supporting. Economy can also be achieved on the capacities of the service reservoirs. It has been observed that due to metering there is no significant reduction in per capita consumption. The reduction in per capita consumption can be expected provided the wat

consumption. The reduction in per capita consumption can be expected provided the water rates are substantially high.

ACKNOWLEDGEMENTS

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MARGINAL PRICING APPROACH TO WATER RATES DEVELOPMENT

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1. INTRODUCTION

The subject of this presentation is "Marginal Cost Pricing in Water Rates Development" and it shall be treated in the following three chapters:

First, a very simple numerical example may help to show in basic terms, what is meant by the concept of "Marginal Costs" for the expansion of a supply system and what is meant, on the other hand, by the more traditional concept of "Average Accounting Costs."

Then, these two cost concepts are explored, seperately as well as in comparison to each other.

And finally, the relevance of "Marginal Costs" to water rates, compared with the one of "Accounting Costs," is investigated.

A word of caution, however, may be in place: No rigorous or exhaustive treatment may be expected here, neither of the many aspects of "Marginal Costs" nor of the complex and sensitive matter of rate setting. By no means should my remarks be taken as practical guidelines for the development of a new rate system. But if your interest in the idea of marginal costs and its usefulness for rate setting would be further stimulated, my words would be fully rewarded.

In case someone wants to pursue the subject any further, a short selection of reference titles may be found on the following page. The inclusion of a World Bank Publication, by Ralph Turvey and Dennis Anderson, on "Electricity Economics," is not by mistake. I found it a very useful and "readable" introduction to marginal costing and rate setting in public utilities, making due allowance of course, to the rather obvious differences between electricity and water supplies.

Selection of References

– Robert J. Saunders / Jeremy J. Warford:

"Village Water Supply – Economics and Policy in the Developing World," A World Bank Research Publication, The Johns Hopkins University Press, Baltimore and London, 1976

– Robert J. Saunders / Jeremy J. Warford / Patrick C. Mann:

"Alternative Concepts of Marginal Cost for Public Utility Pricing: Problems of Application in the Water Supply Sector," World Bank Staff Working Paper No. 259, May 1977

– Ralph Turvey and Dennis Anderson:

"Electricity Economics – Essays and Case Studies," A World Bank Research Publication, The Johns Hopkins University Press, Baltimore and London, 1977

– World Health Organization / World Bank Co-operative Programme: "Republic of Terrania – A case study on the economic and financial aspects of programmes and projects in the drinking water supply and sanitation sector," 1980

2. NUMERICAL EXAMPLE

Let us turn now to the numerical example presented in Annex 1. It shows, first, a list of existing and proposed plants for a hypothetical water supply service. All values are expressed in constant prices and in a currency we may call "Monetary Units."

A first supply system (A) serving 20,000 consumers and requiring no additional water treatment may have been commissioned in 1970. Of its total investment, a portion of 1-1/2 million MU corresponds to civil construction and other long living assets (50 years), whereas 300,000 MU correspond to machinery and equipment with an expected service life of only 15 years.

Additional supply systems (B, C, D) were added later on, or are planned for the future; the same applies to treatment plants, distribution networks, and administration buildings.

On the basis of these investment values, annual costs of service may be calculated according to paragraph 2, including operation and maintenance, administration and general overhead expenses, as well as depreciation and return on capital. Annual water requirements may be estimated according to paragraph 3. Under paragraph 4, the corresponding cost-budget for these items is shown for the five-year period 1981 to 1985, resulting in average costs which increase from 0.66 MU/m^3 in 1981 to 0.72 MU/m^3 in 1985, with an average of 0.70 MU/m^3 over the entire five-year period.

This type of cost calculation may be called the traditional or "accounting method," as it includes historical cost figures for all the plants and assets expected to be in service at some time during the budget period.

On the other hand, the "marginal development costs" in paragraph 5 do not consider all the plants for which investment costs have already been incurred (or sunk), but rather the, new additions planned for the expansion of the different system components such as supply system treatment plants, distribution system, and administration. Annual costs, based on these new additions to fixed assets, are estimated in the same way as before, resulting in total marginal costs (average incremental costs) of 0.82 MU/m^3 for the next stages of system expansion.

It may be noted that in this particular case additional steps of system expansion are generally more expensive than previous ones, which leads to increasing annual "Accounting Costs" and is expressed by an even higher "Marginal Expansion Cost." Other cost relations are of course possible and are indeed encountered in real life, although our case, of increasing unit costs as the system grows, is rather typical for water supply systems.

3. "ACCOUNTING COSTS" AND "MARGINAL COSTS": A CLOSER LOOK AND COMPARISON

Let us now look a little closer at these two cost concepts and try to make some comparisons between them.

According to either concept, annual costs may cover:

- operation and maintenance of the service providing system (including energy costs which often are shown separately)
- administration and general overhead items (some adequate share related to the service system)
- depreciation allowance for the adequate writing-off of fixed assets assigned to the service (including portions of immaterial and general assets)
- return on invested capital (including working capital) as required for attracting the necessary financing.

In our example, admittedly simple methods were used for calculating annual costs. Much more elaborate and sophisticated methods are usually applied to either concept, "Marginal" as well as "Accounting" costs. The purpose of the example was not to illustrate the methods used for estimating annual costs, but rather to stress the different asset basis on which the two cost concepts rely. Whereas "Accounting Costs" rest on the entire plant and equipment park invested in the past and still in operation, "Marginal Costs" consider only the future, typical investments required for expanding the service system according to various components and levels. Historical asset are therefore the basis for "Accounting Costs" whereas future assets are the basis for "Marginal Costs" of system expansion.

The information source for projecting "Accounting Costs" includes the asset accounts reaching back to the investment dates of the oldest equipment still in operation. The people familiar with this type of information are the accountants. One of their major concerns may be how to revaluate their historical investment records in order to reflect present-day price levels.

On the other hand, the principal information source for projecting "Marginal Expansion Costs" is the utility's development master plan and the cost estimates for future investment projects. The people familiar with this type of information are the development planners and cost estimators in the engineering departments. Their main concern may be the selection of the most adequate expansion plan, the setting of priorities between individual projects, their timing, sizing and costing.

These planning activities possibly include a larger share of professional, but still subjective judgment than the previously mentioned accounting exercise. This may be the reason, why "Marginal Costing" seldom produces unquestionable results, and why regulating authorities have been rather reluctant in the past to allow private utilities use the "Marginal Cost" concept for their rate determination.

Economic theory behind the "Marginal Cost" concept holds that a consumer (or producer) tends to increase his demand for a given resource (commodity or service) as long as the ("marginal") benefit derived from the last unit consumed is superior ro the ("marginal") cost attached to that unit (marginal cost-benefit theory).

Theoretically there are no problems in visualizing these consumption-units as infinitely small, and the corresponding demand and supply functions as being continuous. Thus the adjustment process can be smooth and effective. However, practical application has to cope with obstacles such as discontinuous functions, unknown or uneffective elasticities, and first of all, the problem of indivisibility of capital items (leading to investments in relatively large steps and blocks).

It is not surprising, therefore that practical application of the "Marginal Cost" concept to rate setting tries many different ways and means, how to surmount these obstacles and, therefore, is far from uniform. The authors of the World Bank Staff Working Paper No. 259 listed in our selection of references conclude on this subject that "it is not possible to establish a set of precise marginal cost estimation rules which can be followed mechanically in all circumstances. In practice, compromises are required, and the types of compromise that are suitable depend upon the degree of capital indivisibility, the stage of the project and program cycle at which the pricing decision is being made, the relevant elasticities of demand, and, not least, the prices which currently prevail."

Therefore, even if marginal pricing tries to get away from the averages of accounting costs, it still uses, for practical reasons, the average rather than the infinite approach, mainly with respect to consumer groups, asset items, and time spans. After carefully investigating and comparing several alternative concepts for the practical application of marginal costs in the water supply sector, the above mentioned World Bank Paper seems to favour the so called "Average Incremental Cost" method (also known as "discounted unit cost" method).

Average Incremental Cost (AIC) "is calculated by discounting all incremental costs which will be incurred in the future to provide the estimated additional amounts of water which will be demanded over a specific period, and dividing that by the discounted value of incremental output over the period."

In other words, AIC include incremental operating costs plus Marginal Capacity Cost (MCC) which latter can best (but not exclusively) be estimated as:

$$MCC = \frac{\text{Present Worth of the Least Cost Investment Stream}}{\text{Present Worth of the Stream of Incremental Output resulting from the Investment.}}$$

What are then the advantages of "Marginal Cost" pricing against "Accounting Cost" prices, if practical application of the latter often seems less complicated and less debatable, and in any case has been long established? In order to answer this question, we have to look at the different criteria a properly designed rate should be able to satisfy, and evaluate the two cost concepts with respect to the most important among these criteria.

4. EVALUATION OF "MARGINAL COSTS" AGAINST "ACCOUNTING COSTS" FOR PRICING PURPOSES

As the supply of piped water usually is organized by a monopolistic utility, prices in this business are not determined by the interplay of supply and demand as they might be under free market conditions. And if arbitrary rate fixing is to be avoided, some kind of rules for rate setting have to be established and their application has to be watched by public authority.

The basic and most widely used guidepost for a "fair" rate seems to be the "Cost-of-Service." "Accounting Costs" as well as "Marginal Costs" are alternative ways of determining this "Cost-of-Service." The "Cost-of-Service" concept is useful not only for indicating average rate levels, but also for structuring rates in as far as the Cost-of-Service can be differentiated between various user-categories, service levels, delivery points and times.

A utility rate should of course be practical in its metering requirements, applicable without ambiguities, helpful for invoicing and payments, changing as little as possible over time, clear and well understood by the public as to its signalling intentions, etc.

Beside these more technical requirements, the rate system should serve the following principal functions:

- lead to an efficient resource-allocation at the macro-economic level
- generate sufficient funds for the utility's financial requirements
- foster a "fair" distribution of benefits and costs of the service, from the social point of view.

It is mainly with respect to the resource-allocation function that "Marginal Cost" pricing shows its superiority over the "Accounting Cost" concept. "Efficiency" in the allocation and utilization of resources would mean, that a given resource is utilized up to the point where the satisfaction (or product) derived from utilizing it, shows no longer any surplus over the real economic cost attached to the resource.

In order that the consumer can make this value judgment with respect to the amount of water he wants to use, he should be clearly shown, by means of the water rate, what the costs of his consumption to the community are going to be. These costs should therefore reflect the real and present-day situation of availability or scarcity of water at the place where, and the time when the consumer wants to use it.

Such costs, in the meaning of economists, represent "opportunity costs," which means that they express the amount of benefits these same resources could produce if they were utilized at some other place or opportunity in the economic community.

Average "Accounting Costs" which reflect the past accumulation of a utility's equipment park, may be a poor indicator of today's, and even more so tomorrow's resource availabilities. This divergence between historical "Accounting Costs" and the present-day opportunity costs may be particularly large, if one or several of the following conditions prevail:

- if the utility has been long established and carries, on its books, many asset items with a long service life and which have been installed many years ago
- if the relative scarcities of resources involved have been changing, either due to changes in the availability or supply situation, or to changes on the demand side which in a developing service area is nearly always the case
- if processes and equipments required have changed, which may be due to technological or economic developments; this would be the case when increased demand justifies the installation of larger plant units with corresponding economies of scale.

In view of these changing situations, the equipment park of a utility established in the past is not always the most adequate one for attending to-day's service requirements. But on their part, the new investment projects and future development plans can fully take into account the present-day conditions and even their anticipated changes in the future. It is, therefore, the cost of these future plants, not any cost of the past, which should be signalled to the consumer by means of the water rates in order to be weighed against the expected benefits of additional consumption. These future costs are expressed in the "Marginal Expansion Costs" rather than in historical "Accounting Costs."

However, this criterion of efficient resource allocation at the macro-economic level may not be fully compatible with the utility's financial requirements which may include the debt servicing for investments of the past besides the financing of current expenditures and new investments. Yet the generation of adequate funds for the financial viability of the utility, which is the theme of this Technical Session, has certainly to be considered a legitimate purpose of rate setting, in as far as water supply is expected to be a financially self-supporting operation.

The problem of additional fund requirements, above the cost-of-service level, is not particular to the "Marginal Cost" approach, it also exists with respect to "Accounting Costs". In the cases where "Marginal Costs" are above "Accounting Costs", which seem to be frequent in the water supply sector, the financial gap is even reduced when rates are based on the higher "Marginal Cost" level.

From the point of view of "Marginal Cost-Benefit Theory" it seems important that any additional rate-charges which might be required for financial reasons, should interfere as little as possible with the function of efficient resource allocation assigned to "Marginal Cost" – rates. This means that additional rate-charges should preferrably be burdened to such types of water utilization or consumer categories that will not appreciably change their utilization patterns in response to the additional charge, whereas sensitive segments of water consumption, with a high price-elasticity of demand, should be rated as close as possible to their respective "Marginal Costs."

Financial requirements depend of course very much on institutional or budgetary boundaries, i.e. the width of activities; geographical areas, etc., for which financial requirements are determined. It may be e.g. that one and the same utility not only provides water, but is also responsible for water disposal. In such a case, supply and disposal of water. Or it may be, that basic water supply is not considered as a separate goal by itself, but rather seen in the wider context of public health. The costs of basic water services may then be looked at in conjunction with the resources allocated to public health. A third aspect migth be, that rural water districts be subject to the same requirements regarding the generation of funds than residential districts with higher demand densities and capacities to pay.

But this brings us already to the third of our rate criteria, which refers to the social requirement of "fairness", or affordability. Here again, this aspect is not particular to "Marginal Costing" but equally applicable to "Accounting Costs."

Whereas the generation of funds mainly depends on the average rate *level*, this social criterion finds its expression mainly in the rate *structure*. It expresses the notion of equitable sharing of total service costs among the consumers according to their economic capacity.

Again, a compromise might have to be established between the economic goal of efficient resource allocation and the social requirement of providing a given population with basic water services in order to improve its wellbeing and health. The "Marginal Cost" concept in no way impedes this type of compromise. But by establishing as realistically as possible the cost of each additional m^3 of water supplied, it permits to measure the amount of the subsidy the society pays to some of its members in support of social or political goals, as difference between "Marginal Costs" and actual rates.

Before I finish, I should like to mention still another advantage of "Marginal Cost" pricing, which is related to project evaluation. All of us are aware of the enormous difficulties we run into when we try to establish and quantify the economic benefits expected from a water supply project. A meaningful benefit cost comparison then becomes almost impossible. If in these circumstances prevailing rates reflect "Marginal Costs" of system expansion, the planner can be satisfied that these rates, supported by the consumers' "willingness-to-pay", are close to the economic benefits of the service supplied. If corresponding demand at this rate level justifies a system expansion (at costs reflected by the rate level), the economic justification of the project may be assumed.

Examples of Average Accounting Costs and Marginal Development Costs*

1) *Existing and Proposed Plants for Water Supply Service* (in constant 1980 Monetary Units – MU)

Supply system A, for 20'000 consumers (without treatment)		
	commissioned in 1970	1'800'000
	life expectancy: 1'500'000:	50 yrs
	300'000	15 yrs
Supply system B, for 30'000 consumers		
	commissioned in 1976	1'900'000
	life expectancy: 1'600'000	50 yrs
	350'000	15 yrs
Supply system C, for 30'000 consumers		
	to be commissioned in 1981	2'400'000
	life expectancy: 1'800'000	50 yrs
	600'000	15 yrs
Supply system D, for 40'000 consumers		
	to be commissioned in 1984	3'600'000
	life expectancy: 2'400'000	50 yrs
	1'200'000	15 yrs
Treatment Plant X for 50'000 consumers		2'000'000
	commissioned in 1976	
	life expectancy	20 yrs
Treatment Plant Y for 50'000 consumers		1'000'000
	to be commissioned in 1983	
	life expectancy	20 yrs
Distribution Grid; life expectancy		50 yrs
	1970 for 20'000 consumers	200'000
	1976 for 20'000 consumers	300'000
	1980 for 20'000 consumers	300'000
	1982 for 20'000 consumers	400'000
	1984 for 20'000 consumers	400'000
Administration Plant, life expectancy		50 yrs
	1970 for 40'000 consumers	200'000
	1979 for 60'000 consumers	600'000

*These are theoretical cases and serve for illustration purposes only.

2) *Annual Costs of Service*

– operation and maintenance:
  6% p.a. on investments
– administration and general overhead expenses:
  4.- per consumer per year
– depreciation and return on capital:
  sinking fund method (capital recovery factor)
  10% interest p.a.
  life expectancies as indicated in plant schedule

3) *Annual Output Required*

100 litres per consumer per day
or 36.5 m^3 per consumer per year

4) *Average Accounting Costs, Budget 1981 to 1985 (5 yrs)*
(in constant 1980 MU x 1000)
(adjusted to capacity utilization)

		1981	1982	1983	1984	1985	Total 5 yrs
– Operation and Maintenance: Supply systems							
A, B "	:	225	225	225	225	225	1'125
C "	:	48 (1/3)	96 (2/3)	144 (3/3)	144	144	576
D "	:	–	–	–	54 (1/4)	108(1/2)	162
Treatment Plant							
X "	:	96 (4/5)	120 (5/5)	120	120	120	576
Y "	:	–	–	22 (1/5)	43 (2/5)	65 (3/5)	130
Distribution							
exist.	:	48	48	48	48	48	240
future	:	–	12 (1/2)	24 (2/2)	24	24	84
		–	–	–	12 (1/2)	24 (2/2)	36
– Admin. + General OH		240	280	320	360	400	1'600
– Depreciation + Return	:						
Supply Systems							
A, B, 50 yrs		313	313	313	313	313	1'565
15 yrs		85	85	85	85	85	425
Supply System							
C, 50 yrs		61 (1/3)	121 (2/3)	182 (3/3)	182	182	728
15 yrs		26 (1/3)	53 (2/3)	79 (3/3)	79	79	316
Supply System							
D, 50 yrs	:	–	–	–	60 (1/4)	121 (2/4)	181
15 yrs	:	–	–	–	40 (1/4)	79 (2/4)	119
Treatment Plant							
X	:	188 (4/5)	235 (5/5)	235	235	235	1'128
Y	:	–	–	42 (1/5)	84 (2/5)	127 (3/5)	253
Distribution							
exist.	:	81	81	81	81	81	405
future	:	–	20 (1/2)	40 (2/2)	40	40	140
		–	–	–	20 (1/2)	40 (2/2)	60
Administration							
1970	:	20	20	20	20	20	100
1979	:	20 (2/6)	30 (3/6)	40 (4/6)	50 (5/6)	61 (6/6)	201
Total Ann. Costs		1'451	1'739	2'020	2'319	2'621	10'150
Consumers served		60'000	70'000	80'000	90'000	100'000	400'000
Consumption M^3 x 100		2'190	2'555	2'920	3'285	3'650	14'600
Average cost per m^3 (MU/m^3)		0.66	0.68	0.69	0.71	0.72	0.70

5) *Marginal Development Costs, 1981 to 1985* (in constant 1980 Monetary Units)

– Supply System:

The next stage in expanding the supply system corresponds to system D, to be commissioned in 1984, which is the least cost solution for expanding supply at the present development stage. Its annual costs are expected to be:

– operation and maintenance	1000 MU:	216
– Depreciation and return (expressed in a constant magnity equivalent to the discounted investment stream)	1000 MU:	400
Total per year	1000 MU:	616
Annual capacity	1000 m^3:	1460
Average incremental cost of supply system	MU/m^3 :	0.422

– Treatment Plant:

(complementary to Supply System D)

Treatment Plant Y, for a capacity of 1'825'000 m^3 and an investment cost (Present worth at commissioning date) of 1'800'000 MU is scheduled to be commissioned in 1983. Its annual costs, considered to be representative for the next expansion of treatment plant capacity, are expected to be:

– Operation and maintenance	1000 MU :	108
– depreciation and return	:	211
total per year	1000 MU :	319
Average incremental cost of treatment plant MU/m^3		:0.175

– *Distribution*

Expansions to the distribution system are scheduled for 1982 and 1984, with similar unit costs which are considered as representative for the next expansion of distribution capacity. These annual costs are expected to be:

– Operation and maintenance	1000 MU :	24
– Depreciation and return	1000 MU :	40
Total per year	1000 MU :	64
Average incremental cost of distribution system (annual capacity 730'000 m^3	MU/m^3	0.088

– *Administration*

Although no further expansion of administrative capacity is planned for the time being, the costs of the 1979 expansion may be taken as an indication of present expansion costs. Corresponding annual costs are:

– Operation and maintenance	1000 MU :	240
(in 1981) for an annual output of 2'190'000 m^3 average	MU/m^3	0.110
– Depreciation and return on 1979 Plant:		
1000 MU		61
for 60'000 consumers or 2'190'000 m^3 annual output average	MU/m^3	0.028
Total administration	MU/m^3	0.138

– *Total Marginal Development Cost per m^3*

– Supply system	MU/m^3 :	0.422
– Treatment Plant	"	0.175
– Distribution	"	0.088
– Administration	"	0.138
Total Service	MU/m^3	0.82

MINIMIZING UNACCOUNTED FOR WATER (With Emphasis on Leak Repair)

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INTRODUCTION

Definition of Terms

'Unaccounted-for water' as used in this paper in the amount of water, usually expressed in percentage of the total volume of water produced, from which no revenue is derived. In this sense, unaccounted-for water can also be defined as the sum of non-revenue water used and the water lost. The unaccounted-for water (UW) has always remained high through most of the history of the Metropolitan Waterworks and Sewerage System (MWSS), averaging about 49% from the period from 1970-1978. In 1979, the UW was down to only 46.8%; in 1980, 46.5%.

Factors Contributing to UW

The relatively high volume of unaccounted-for water can be expected of a system as old as that of the MWSS. It must be noted that the first water system in Manila dates back to 1881 with the completion of the original Carriedo Waterworks which formed the beginnings of the MWSS network. The high UW can also be directly attributed to inadequate maintenance activities as a result of low income levels prior to 1978.

Factors affecting unaccounted-for water include water losses, measurement errors and unauthorized or free water use. The MWSS network being an old system, a large portion of the pipe network is expected to have reached their useful life and are therefore prone to leaks. However, only a fraction of the potential leakage points are actually leaking due to the relatively low service pressure prevailing in the system. It is only after repairing a substantial number of leaks when the pressure increases and then other leak prone points develop new leaks. In this manner a "recurrence" of leakage may be observed when in fact it is only a case of delayed leakage due to inadequate water supply to build up the pressure.

With the advent of the current Manila Water Supply Project II, which is jointly financed by the International Bank for Reconstruction and Development (IBRD) and the Asian Development Bank (ADB), various activities have been implemented since 1976, all aimed at gradually reducing the unaccounted-for water. These measures have been accompanied by serious efforts at a more strict accounting of water. On the other hand, in order to finance the project and to help in the repayment of the loan, it has been necessary to increase water rates. With increased water rates come additional funds for more adequate maintenance activities.

PROGRAM TO REDUCE UNACCOUNTED-FOR WATER

Rationale

Having established the fact that water losses, measurement errors and unauthorized or free water use all contribute to unaccounted-for water, the effort to reduce unaccounted-for water have been directed towards the control of these factors. Table 1 shows the various projects and activities directed at the reduction of unaccounted-for water.

TABLE I

PROGRAMS/PROJECTS FOR REDUCTION OF UNACCOUNTED-FOR WATER (UW)

Factors to be controlled	Program/project for the Control of the factor	Resource Allocation		Estimated Contribution to UW %		Estimated Reduction in 1980 %	Estimated Contribution to UW by the end of 1980 (%)
		Sub-Total	% of Total	1976	1979		
Water Losses	Leak Detection Accelerated Leakage Control Elimination of Spaghetti connections and transfer of tapping to nearest main Repair, rehabilitation of valves, and hydrants	P23,344,181	85.9	25.7	24.9	0.1	24.8
Measurement Errors	Metering Program Large Meter Testing Monitoring Unaccounted-for Water by Area and Flow Instrumentation for pump stations	2,523,950	9.3	15.4	11.9	0.1	11.8
Unauthorized or Free Use	Public Faucets and Hydrant monitoring	850,420	3.1	8.5	10.0	0.1	9.9
Efficiency in Operation	Training Program Performance Appraisal System	457,470	1.7				
TOTAL		P27,176,021	100%	49.6	46.8	0.3	46.5

The program is a comprehensive one as it includes auxiliary activities which are designed to improve the efficiency in the operation of the existing organization involved in the reduction of unaccounted-for water. Thus, included are an Action Center for improving communications, a training program for developing skills and work methods, and a performance appraisal system for enhancing supervision and control of field activities.

Components of the Program

As originally conceived in January 1980, the comprehensive program for the reduction of unaccounted-for water includes the following projects and activities:

1. Programmed leak detection
2. Accelerated leakage control
3. Elimination of "spaghetii" connections and systematic transfer of water service connections to the nearest water mains
4. Repair, replacement and rehabilitation of valves and hydrants
5. Metering program
6. Testing of large meters
7. Periodic measurements of unaccounted-for water
8. Installation and metering of public faucets and monitoring of usage of fire hydrants
9. Organization of an action center
10. In-service training program for unskilled personnel
11. Performance appraisal

The leak detection program started in 1976 is a year-round, night-time activity involving the continuous survey of the entire water distribution system for leakages with the use of electronic sound intensifiers or leak detectors. This is done by trained personnel during the night when sound interference is low and road traffic is at a minimum.

Started in 1977, the accelerated leakage control program involves the systematic repair and rehabilitation of water service connections and the secondary and tertiary mains found to be leaking in the water distribution system. At the peak of implementation a total work force of 48 teams supported by adequate supervisory, clerical and monitoring staff ran the program daily on a round the clock basis, seven days a week.

The program for the elimination of "spaghetti" connections which started in 1978 involves the removal of long water service pipes criss-crossing the sides of streets by extending new water mains into densely populated areas which lack water mains. The elimination of these long connections is designed to substantially reduce the occurrence of service line leakages, ease-up the repair and/or replacement of the same and expedite the identification of individual water service connections. It also reduces the incidence of illegal tappings from long water service connections.

The program for the systematic transfer of water service connections to the nearest mains was started in 1978 and seeks to reduce water losses due to leaks and illegal water use and, in the process, to improve the mode of distributing water to the individual concessioners. The program incidentally results in the discovery of illegal connections and the unearthing of defective and leaking pipes.

Originally, after a study had been made on its feasibility, a program was proposed in 1979 for the repair and restoration of streets by MWSS personnel. By undertaking this activity which is now being performed by the Ministry of Public Works and Highways, MWSS can reduce overhead expenses and at the same time enhance the early repair of the streets. Experience shows that excavations along busy streets, although properly backfilled but not restored immediately, can result in the recurrence of leaks. However, when the program was presented for approval, some resistance was met from various quarters. Some people felt that the function of repairing and restoring streets properly belonged to the MPWH, and that it was an activity foreign to the MWSS. Thus, despite the demonstrated economic and technical feasibility of the proposal, it has been decided to limit the application of the concept to major construction projects only. Roadways excavated for purposes of leak repair and water service installation are still restored by the MPWH.

The program for the repair and rehabilitation of valves and hydrants aims to improve the water distribution control facilities which heretofore had been rather neglected. Relying heavily on casual laborers for manpower, the program seeks to survey the whole central water distribution system. It was started in 1978.

The Metering Program is being implemented by a Metering Task Force under the MWSS Office for Special Projects (OSP). It is a component of the Manila Water Supply Project II (MWSP II) and involves the supply and delivery, initially, of 200,000 domestic water meters. Of these meters 182,564 have laready been installed. Under-registration of defective meters has been the bane of the system. Sutides show that where water services are not metered and billing is based on previous average readings, MWSS usually ends up at the short end. The Meter Replacement Program is geared to correct this disadvantageous situation.

Also started in 1976 the Large Meter Testing Program is another year-round, day-time activity involving the in-place testing of large water meters (sizes 3" through 8") for relative accuracy determination, and repair on replacement if round defective. It is estimated that large meters, measure more than half of the total metered water disfor a more prudent and equitable allocation of water for municipal/domestic water supply users. Because it is felt that the present per capita per day allocation to water users for such purpose are inequitable and are dictated by force of circumstances rather than actual needs and generally are intended for planning purposes. Consumption statistics obtained from reports of various water supply agencies, such as the Metropolitan Waterworks and Sewerage System, Local Water Utilities Administration and Rural Waterworks Development Corporation reveal that:

For Metro Manila area	– 300 liters per capita per day (LPCD)
Other urban areas	– 250 lpcd
For rural areas	– 60-100 lpcd.

The higher urban areas per capita consumption is mainly due to adequate distribution facilities although sometimes it is limited by conditions of law pressure in the main. In the rural areas, inadequate water supply distribution facilities are major factors in limiting per capita consumption while in areas supplied by public faucets, consumption is usually limited by the need to carry water from the faucet to the house.

For general planning purposes the above figures are deemed sufficient at the moment, however for more equitable policy in allocating water rights, a uniform value should be adopted anywhere nationwide. The reason behind this is that, while certain limitations exists in the use of water, it is also a fact that a user no matter where he lives has a much as the same right to the same amount of water those in more developed areas.

The Council therefore unanimously agreed to grant 250 lpcd irrespective of location to water supply applicants.

D. Shift from Agro to Agro-Industrial Economy

Proposals for Reform –

1) When the Philippine Water Code was promulgated, the basic economic policy of the Philippines was agricultural. It is not surprising, therefore, that agricultural connected water uses enjoy preference over industrial use.

Recently, however, there is an accelerated shift to agro-industrial economy. In this light, it is opined that a re-assessment of priorities should be undertaken – that is industrial use be elevated to the level of irrigation use, if not above such level.

In other countries the first order of preference when priority in time of appropriation cannot be determined is "Domestic and Industrial Use." It is pretty obvious therefore, that Industrial use of water ranks higher in priority than that of irrigation and in fact enjoys the same preference for domestic or municipal use. Reasons for such change in priority is not wanting. In the classification of waters according to National Pollution Control Commission's Standards, CLASS D waters may be used for irrigation purpose but not vice-versa, more so when water is a necessary ingredient for an industrial output. Let me hasten to add however, that the shift of priorities should not be total. Only those industries which are considered "Clean" under NPCC standards should be elevated.

2) A feasibility study should be initiated regarding the re-use of water. The possibility of adopting the suggestions made by the California State Department of Water Resources and the State Water Resources Control Board whereby water permits must incorporate provisions for reuse or reclamation of water for human consumption should be considered. In our jurisdiction, while we do not disregard reuse of wastewater when feasible, we see to it that it shall be limited as much as possible to such uses other than direct human consumption, and no person or agency shall distribute such water for public consumption until it is demonstrated that such consumption will not adversely affect the health and safety of the public.

It would not be out of context if I exude confidence, that with the association's wide, competent and its geographically extended membership, a unique, if not outstanding contribution in the field of water law, specifically in water rights allocation, can be made.

thereof, restated in Section 8, Article 14 of the 1973 Constitution which in part provides:

> "All lands of the public domain, WATERS, MINERALS, COAL, PETROLEUM and other MINERAL OILS, all forces of potential energy, fisheries, wildlife, and other natural resources of the Philippines belong to the state. x x x x x."

Explicit from the afore-cited provisions is the fact that the State no longer recognizes private ownership of water – a radical innovation vis-a-vis the counterpart provisions of the Spanish Law of Waters and the Philippine New Civil Code of 1950.

B. Control, Regulations, Disposition and Management

Basis –

The basis for the State's control, regulations, disposition allocation and management of water resources is a necessary implication of the Regalian doctrine. The state being the owner of all waters can exercise all the attendant attributes of ownership. As provided in Art 4 of P.D. 1067 otherwise known as the Water Code of the Philippines, waters referred to are the water under the ground, water in the atmosphere and waters of the sea within the territorial jurisdiction of the country.

Cognizant that water is one of the most important, if not the most among the natural resources, the government opted for stricter control and regulation in the utilization, exploitation, development, conservation and protection of this essentially consummable commodity. When the State thru the Water Code vested in a single agency, – the Council control and regulation of the nation's water resources, it giveth life to the enunciation in the Preamble of the Constitution, that the Government shall "conserve and develop the patrimony of our Nation."

C. Priorities/Preference

To ensure a balanced-beneficial use according to importance, demand, the State's socio-economic, ecological, aesthetic and political policies, the Philippines Water Code set an order of preference for the guidance of the Council in the allocation of water rights. Thus –

Article 95 of P.D. 1067 provides –

"xxx.

When priority in time of appropriation from a certain source of supply can not be determined, the order of preference in the use of the waters shall be as follows:

a) Domestic and municipal use
b) Irrigation
c) Power generation
d) Fisheries
e) Livestock
f) Industrial use, and
g) Other uses."

Apparently, the Philippines, under this Article, subscribes to the Doctrine of Prior Appropriation as adhered to by the States of Nevada, Idaho, Montana, Wyoming, Utah, Colorado, Arizona, New Mexico and Alaska.[4]

This order of preference is resorted to only when priority in time of appropriation, can not be ascertained.

The doctrine states that the first in time to use the water beneficially is the first in right.[5] Its modern-form conception is governed by three basic principles:

1. The State claims and control over water, allowing private persons to acquire rights only by virtue of a State permit;
2. Permitted uses of water must be reasonable and beneficial; and,
3. The water users have property rights protected against infringement from later users, existing, in perpetuity if used and in most instance transferable by the owner to another person.[4]

However, Article 95 is qualified by Article 22 to the effect that time of appropriation is not the sole yardstick for the determinations of priority. Specifically, Article 22 provides "Between two or more appropriators of water from the same source of supply, priority in time of appropriations shall give the better right, except that in times of *emergency* the use of water for domestic and municipal purposes shall have a better right over all other uses; *PROVIDED*, that where water shortage is recurrent and the appropriator for municipal use has a lower priority in time of appropriation, then it shall be his duty to find an alternative source of supply in accordance with conditions prescribed by the Council.

This Article has s striking similarity with the California Water Code which provides –

"it is hereby declared to be the established policy of the State that the use of water for domestic purposes is the highest use of water the next highest is for irrigation."

C. Guidelines/Criteria in Determining Municipal/ Domestic Water Supply Requirements for Water Rights Allocation

Lately, the Council adopted some guidelines

4"Contemporary Developments in Water Law:, Edited by Corwin W. Johnson and Susan H. Lewis. Vol. IV. p. 75.

5"Relationship Between Water Quality and Water Rights," Ronald B. Robie – Member, State Water Resources Control Board, State of California. p. 75.

Decree No. 1067, otherwise known as the Water Code of the Philippines.

A SURVEY OF PHILIPPINE WATER LAWS RELATIVE TO WATER RIGHTS ALLOCATION

The arrival of Ferdinand Magellan in this country on 16 March 1521 presaged a new era in the history of Philippine Law. Spanish laws and codes were extended to the Philippines either expressly by royal decrees or by implication by the issuance of special laws for the island.[2] As we are dealing in waters the most important piece of legislation is –

A. The Spanish Law of Waters of August 3, 1866 or Ley The Aguas

This law recognizes the existence of private and public ownership of water. However, it dealt only on 2 classes of water: surface and subterranean.

With respect to privately-owned water, the owner has the absolute right to the enjoyment of all the attributes of ownership limited only by the Latin maxim "sic utero tuo ut alienum non laedas" use your property so as not to injure the rights of others. Ergo, the matter of allocating water rights does not set-in.

It is only on the area of publicly-owned water where allocation becomes relevant. A perusal of the law would indicate a simplistic procedure in water rights allocations – usually reporting the use to the Governor-General. The enjoyment of public surface waters is based on the doctrine of riparian rights – where riparian owners can utilize waters passing thru parallel to their land. Subterranean waters are owned by the owner of the land where drawn – the basic tenet is "the accessory follows the principal." Thus, allocation depends on the character of the water.

In allocating water rights the order of preference, provided by law should be considered. Thus, Article 207 of the Spanish Law of Waters provides – "In the granting of concessions to use public waters, the following order of preference should be observed:

1. The supply of towns and villages
2. The supply of railroads
3. Irrigation systems
4. Navigation canals
5. Mills and other factories, ferry boats, and floating bridges
6. Ponds for breeding fish

Within each class the enterprise of greater importance and utility shall be preferred, or under equal conditions, the parties first filing a petition."

The termination of the Spanish American War followed by the signing of the Treaty of Paris on December 10, 1898 paved the way for the cession of the Philippines to the United States. Upon the establishment of American Sovereignty, the political laws of the Philippines were totally abrogated and Spanish laws, customs and rights of property inconsistent with the US Constitution and with American principles and institutions were superseded. The government operated under different organic laws, namely: President Mackinley's Instructions to the Second Philippine Commission on April 7, 1900; The Spooner Amendment of 1901, the Philippine Bill of 1902 and several other laws.[3]

It is during the American Era and the Commonwealth, or to be specific in the year 1912 that Act. No. 2152 was enacted. It was otherwise known as the –

B. Irrigation Act of 1912

A slight change was made under Act. No. 2152 as regards to priorities.

"Section 3 – Priority of appropriations shall give the better rights between two or more persons using the public waters. In determining the priority, the non-user of the waters for a period of five years shall extinguish any claim of priority unless such non-user shall have been caused by force majeure. When the waters of any source of supply are not sufficient for the service of all those desiring the use of the same, and when priority of appropriations cannot be established the order of preference shall be as follows:

a) Domestic purposes
b) Agricultural purposes or power development for agricultural purposes
c) Industrial purposes
d) Ponds for fisheries
e) Mining purposes or milling connected with mining purposes."

PRESENT PHILIPPINE POLICY

A very significant, albeit, revolutionary concept of ownership of waters was enunciated when the Filipinos were granted the rights to formulate their own Constitution in 1935, and that is –

A. State Ownership of all Waters –

The Philippines adheres to the Regalian Doctrine insofar as ownership of national resources is concerned, that is "All waters belong to the State." This doctrine is clearly laid down in the 1935 Constitution (Philippines), Section 1, Art XIII

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[2] "The Legal System and Literature of the Philippines" Myrna Feliciano – Professorial Lecturer – UP College of Law.

[3] Sinco, Philippine Political Law 85 (11th ed., 1962)

ALLOCATING WATER RIGHTS — Philippine Context

by ATTY. JESUS DE LEON

National Water Resources Council
Philippines

INTRODUCTION

The heart of modern day water legislations is on the mechanics of allocating water rights. Indeed, the efficacy of any water resources management policy depends on the beneficial, regulated and controlled utilization of water rights.

This study, therefore, addresses itself to the queries: What and Why the allocation of water rights, Is allocation relevant when resources are abundant?

Succinctly stated, allocating water rights refer to the granting or recognition of existing water rights with the end in view to developing, conserving, protecting water resources and maximizing their beneficial use. It may also refer to the determination of priorities of rights – both in point of time and preferential use.

Corollarily, the questions of whether a political jurisdiction recognized the existence of public and private ownership of water or to apply either the doctrine of riparian rights or the doctrine of prior appropriation seems to be the "$64 question."

As to the question of Why? The response is obvious – optimum utilization conservation and protection of water resources to meet present and future needs is the order of the day. Indiscriminate allocation or unregulated water rights leads to scarcity, worst exhaustion of water resources. Today, maybe a-plenty, but tomorrow, nothingness. And, as one water management expert said, "A stream may run dry in *law* long before it does so *in fact.*"

Also, when we speak of "Water Rights Allocation" perforce presupposes the existence of an authority authorized to regulate and allocate water rights. In the Philippines, such authority is vested with the National Water Resources Council which for purposes of this study shall be referred to as the Council.

The Council is a fairly recent (1974) and innovative development insofar as water resources management in the Philippine is concerned. Primarily, its creation precipitated from the need to coordinate and integrate the multifarious plans and programs instituted by the various governmental and quasi-public agencies. It also gave life to the constitutional provisions – both 1935 and 1973 – declaring state ownership of all waters within Philippine territory.

By nature, the Philippines is endowed with abundant water resources. Its average annual rainfall is about 2500 millimeters. Dependable supply from rivers is estimated at about 700 million cubic meters per day. This is more than twice the needs of the whole country for the next twenty years. Groundwater reservoirs are found extensively in the plains where most of the people live.[1]

It is asked, is there a real need to create the Council to regulate and allocate water rights in the Philippines?

Apparently, the Council meant another surplusage-agency in government and only complicate the off-repeated complaint of bureaucratic red tape, but, on second look it simplifies, as it coordinates and integrates, the otherwise uncoordinated and unintegrated water resources management activities thus, resulting to the rational utilization of a vital natural resource-water.

Abundance, there maybe, but the Council is not complacent and to ensure adequate water supply, it initiated the assessment of Philippine Water Resources in relation to the potential demands up to the year 2000. For how can we talk of water rights allocation if there is no water for supply in the first place?

To understand the Philippine policy on water rights allocation, it is imperative to conduct a survey of the antecedent legislations of Presidential

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[1] Philippine Water Resources Policies – An Appraisal Angel A. Alejandrino – Executive Director, National Water Resources Council (Philippines) – P.I.

d. Many of the pumps do not perform according to their specifications.

2. Water Level. We also obtain water level data at least monthly. By observing water levels, we are able to prevent motor burn-outs caused by non-lubrication and/or stop-go-stop-go operations.

3. Electricity consumed. We also demanded the installation of electric meters to obtain accurate power consumptions. An increase in consumption of electricity warned us of impending trouble in the pump or in the well itself. Also, electric bills paid to the electric company are more accurate if metered instead of estimated.

4. Voltage and Current. Electric current readings can help prevent costly shut-downs and repairs. Slight increases in electric current will signal impending motor trouble or burn-outs. Voltage readings will show you the periods when voltage is poor and can be detrimental to your motor. We shut-down our pumps if the electric company can not correct the voltage deficiency.

5. Repair and Maintenance Costs. This data has guided us in our decision to abandon some wells. Also, this data can help direct your attention towards the quality of the water in the well or defects in the construction of the well.

6. Elevations and Location. Together with the other data, elevation and location helped us prioritize our attention and expenditures.

High Zone				Highest Priority
Middle Zone				
Low Zone				
Lowest Zone	Lowest Priority			
	Mini Wells	Small Wells	Medium Wells	Large Wells
	YIELD			

BENEFITS

1. The major benefit we derived in gathering groundwater data is the "education and enthusiasm" of our operators. Our operators are now more interested in their work and we've had less turn-overs or requests for transfers.
2. Our Operation and Maintenance costs have been decreasing. During periods of low demand, we shut-off high energy consuming pumps. In some cases we've abandoned some wells.
3. Groundwater Data has helped us anticipate shut-downs. . .thereby preventing embarassing burn-outs and costly repairs.
4. We are now able to maximize or optimize the yields of the wells.
5. Groundwater Data has provided hints of where to drill next.
6. We are now able to size our replacement pumps properly.

If you are dependent on groundwater like we are, we strongly recommend you obtain groundwater data regularly. It's very simple to do. The investments are small. The benefits are enormous.

OPERATORS SHOULD GATHER GROUNDWATER DATA

by HERMINIO C. BAUTISTA

General Manager
Baguio City Water District
Philippines

THE DISTRICT

The city water system was established in 1909 by the Americans who first developed the city. The first facilities were a steam-powered pump to boost 80 gpm of spring water and a 10,000 gallon wooden reservoir atop one of the hills in the central business area. Since then, the system has grown. However, the water system could not cope with the growing population. In 1954, deepwell drilling was introduced to the city.

In 1975, the City Government turned-over the waterworks to the Baguio Water District.... a quasi-public corporation.

In 1980, an intensive rehabilitation of the water system begun. The project which costs $7.5 million is expected to be operational by the end of 1981.

SUPPLY

The present supply system consists of deepwells and springs. During winter, supply is mostly from springs. During summer, supply is mostly from deepwells.

At present, we have 27 deepwells. Nine are not in operation.

The wells yield from 35 gpm to 1500 gpm. Static water levels vary from free flowing to 40 meters. Rainfall and amount of discharge are the two main factors that affect the water levels of our wells.

The wells are all located within the district. Elevations between wells vary by as much as 220 meters.

All our pumps run on electricity. Use of diesel engines is very limited. In 1976, 48% of our revenues was used to pay for electricity. This has been brought down to 18%.

We now operate three mini-hydro electric generating stations. These stations helped reduce our cost of electricity.

GROUND WATER DATA

There are basically two kinds of groundwater data.

1. Those obtained before, during and immediately after drilling. . .referred hereto as Driller's Data.
2. Those obtained months and years after drilling. . .referred hereto as Operator's Data.

Dr. Zvony Haman will explain the importance of Driller's Data.

Allow me to expound on the benefits of gathering operators data.

As an operator of a system, I've discovered

1. In many cases, even driller's data is not obtained.
2. Most hydrologists emphasize driller's data only.
3. Many drillers data are erroneous(?) This is because of
   a. limited time to make the measurements.
   b. incompetent personnel.

OPERATORS DATA

The data we obtained after months and years of drilling are:

1. Yield. This is the most important data and the most simple to gather.

We invested on water meters to accurately determine the amount of water pumped.

By installing a water meter, we discovered the following:

a. The yields of the wells are very different from those reported by the drillers when they drilled the well.
b. Well capacities vary between seasons.
c. The characteristics of the pumps installed do not match the characteristics of the wells.

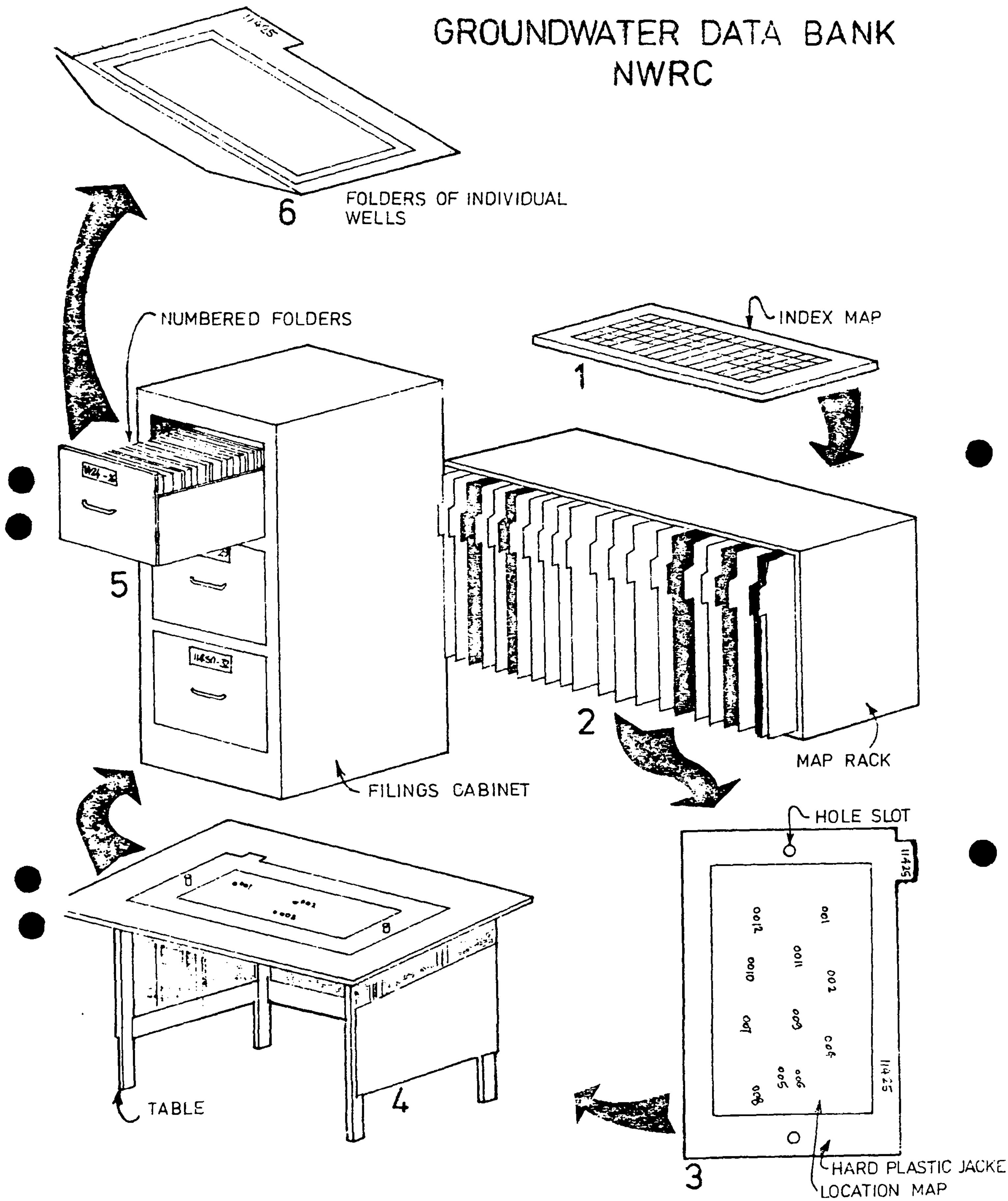


Fig. C6 Office Equipment for Well Records and Base Maps.

Figure C5

FLOW DIAGRAM SHOWING SEQUENCES OF WORK FOR RECORDING OF EXISTING BOREHOLES INTO NWRC GROUNDWATER DATA BANK

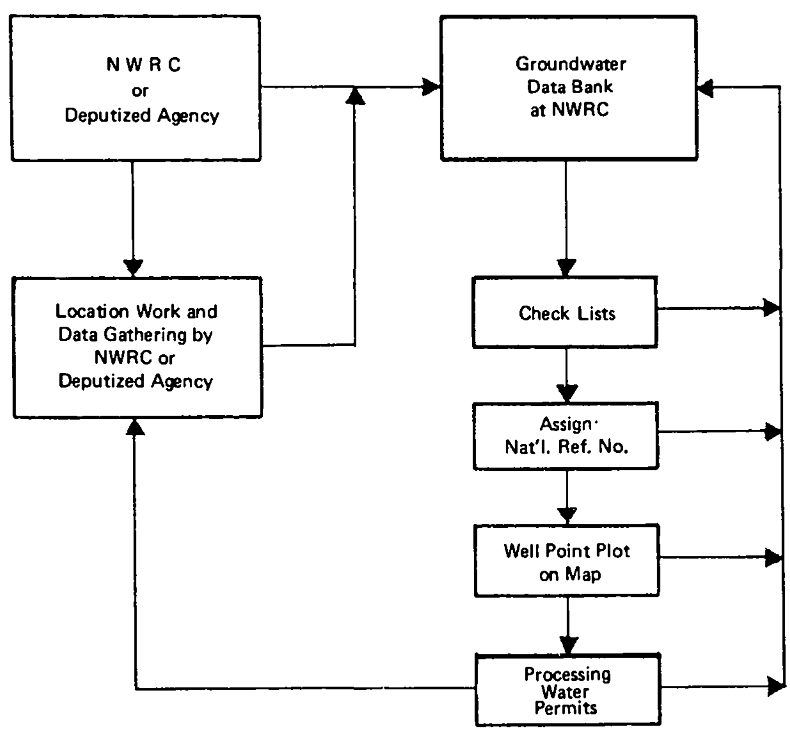
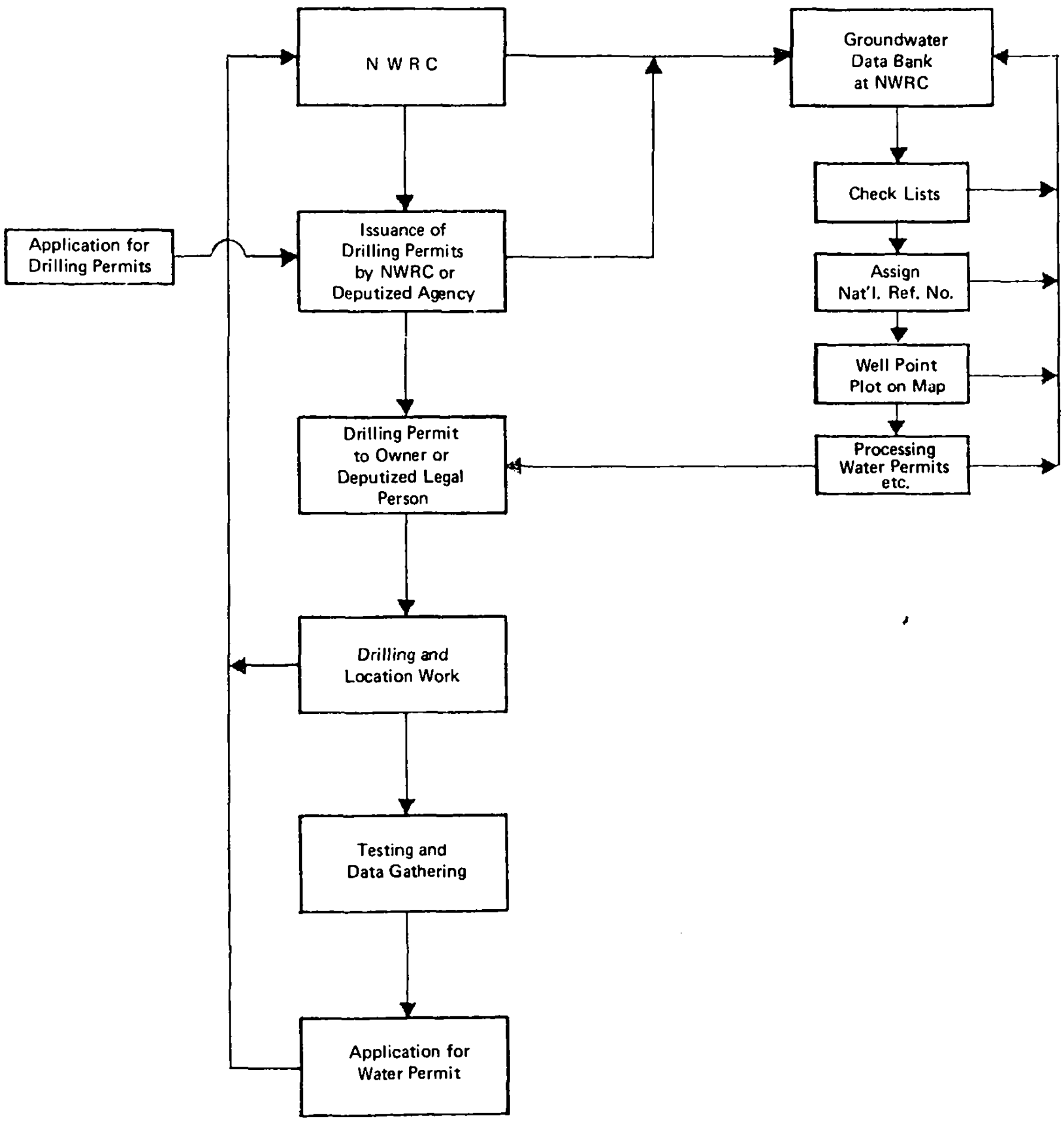


Figure C4

FLOW DIAGRAM SHOWING SEQUENCES OF WORK FOR RECORDING OF NEW BOREHOLES INTO NWRC GROUNDWATER DATA BANK



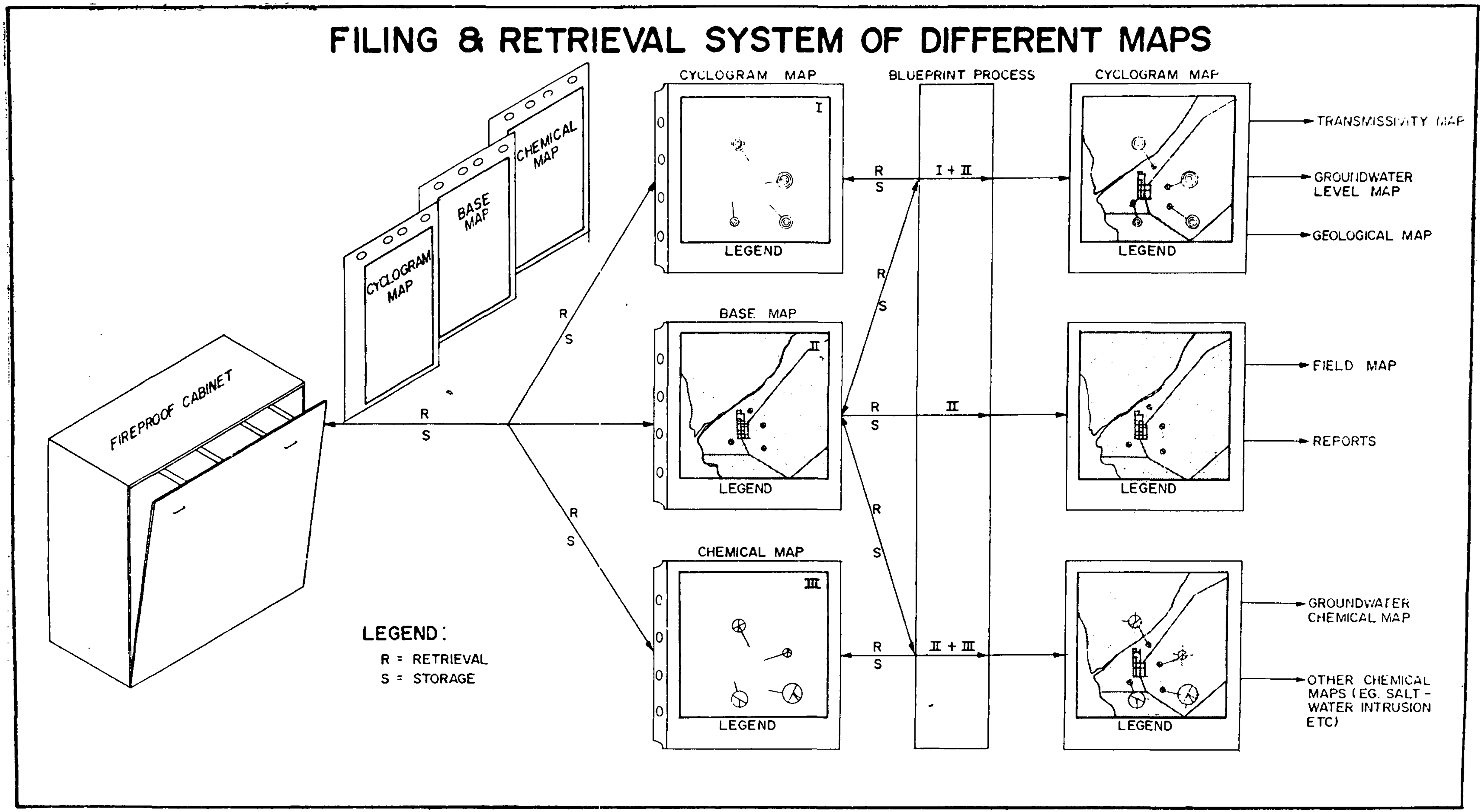


Fig. C3 Filing and Retrieval System of Different Maps.
LWUA's Groundwater Data Bank.

BASE MAP SYSTEM

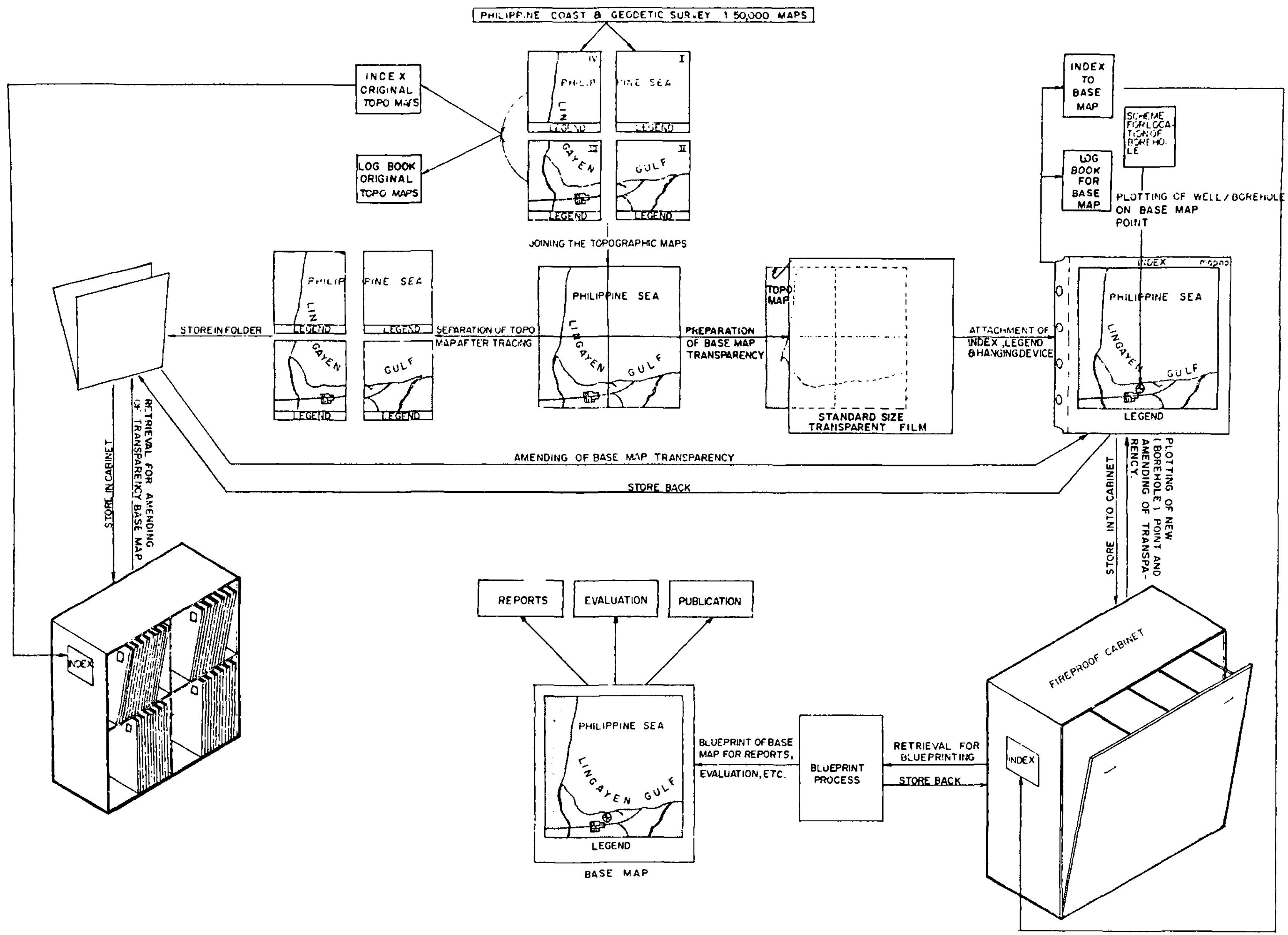


Fig. C2 Base Map System - LWUA's Groundwater Data Bank.

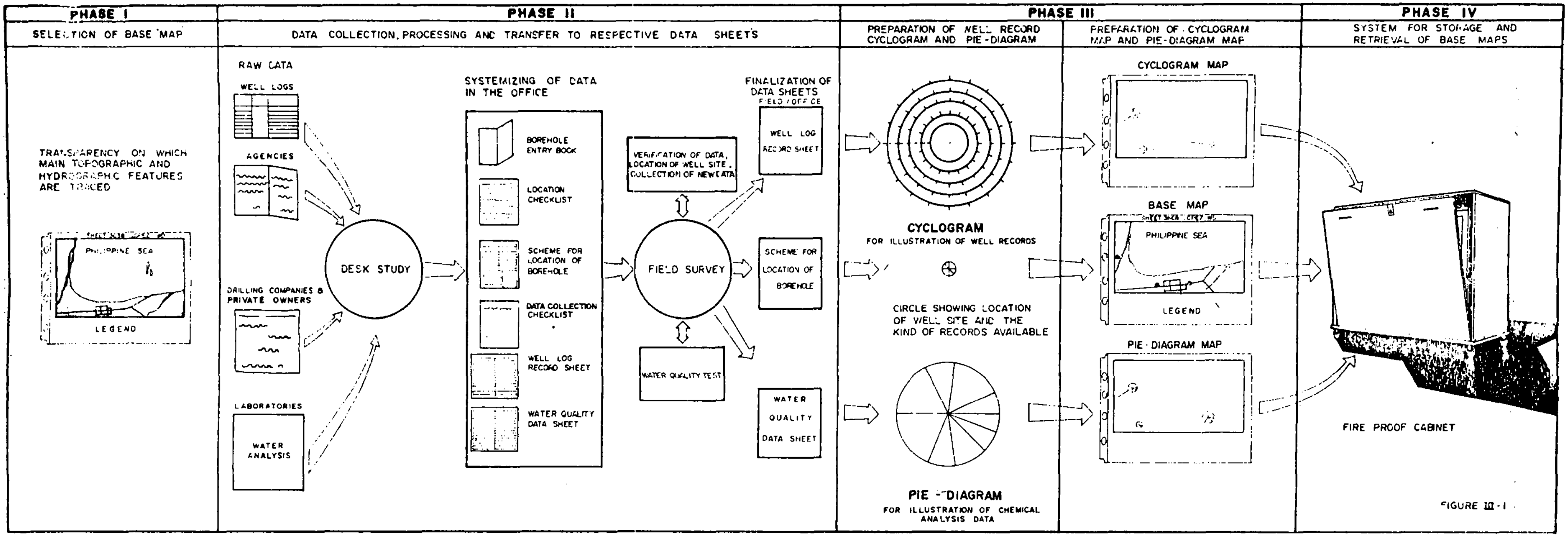


Fig. C1 Phases of establishment of LWUA's Groundwater Data Bank.

(C) PART THREE

EXAMPLES OF GROUNDWATER DATA BANKS ESTABLISHED IN THE PHILIPPINES

INTRODUCTION

The presence of many shallow and deep wells in urban and rural areas indicate the groundwater is utilized extensively in the Philippines.

Several agencies headed by the National Water Resources Council of the Philippines (NWRC) are involved in the exploitation of the groundwater resources.

For the communities with less than 20,000 inhabitants, the Rural Water Development Corporation (RWDC) is the governing agency.

For Metro Manila, the Metropolitan Water and Sewerage System (MWSS) directs planning and use of the water resources.

For the communities with 20,000 inhabitants and more, with the exception of the Metro Manila, the Local Water Utilities Administration (LWUA) is the official body for planning and development of the water resources and water supply systems.

Each of the above mentioned agencies has undertaken data collection and evaluation of the groundwater sources.

In the following sections some examples of establishment of the Groundwater Data Banks will be described and illustrated.

LWUA'S GROUNDWATER DATA BANK (GDB)

For each community exceeding 20,000 inhabitants, a Water District (WD) will be formed. It is expected that approximately 700 Water Districts will be established in the Philippines at the turn of the century. Consequently, approximately 50% of the total Philippine population will be provided with piped water via Water Districts by the year 2000.

As groundwater sources play an important role in the urban water supply, the importance of systematic data collection, evaluation and planning of groundwater sources development, has been recognized by LWUA. Consequently, in the early 1979, the Groundwater Data Bank section was formed, within the Hydrogeological Division of LWUA, with a duty to provide data base required for an efficient development of groundwater sources.

Initially, LWUA's GDB was staffed by three engineers supported by one draftsman, a secretary and a consultant. By the end of September 1980 the GDB staff consisted of 8 engineers, two draftsmen, a secretary and one consultant.

In the initial stages of GDB establishment, two pilot projects (Batangas and Baguio Water Districts) were selected to introduce the procedures for collection of groundwater data and to train LWUA's staff. The cities of Batangas and Baguio were selected as they represent two typical hydrogeological and geomorphological environments in the Philippines.

The Consultants' (Kampsax-Kruger) task was related to the transfer of know-how and assisting in establishment of the system as described in the previous sections.

To date (September 1980), LWUA's GDB has established well records system for about 40 Water Districts. The mapping of well records by cyclogram method and groundwater feasibility studies is carried out for more than 20 Water Districts. Establishment of GDB for other Water Districts (about 170 WD, status mid 1981) is in progress and the cyclogram mapping is carried out as a part of groundwater investigations for future water supply systems. A water quality data collection system was also established in 1980 so the investigations regarding both water quantity and water quality will be simultaneously carried out in future LWUA groundwater projects.

In Fig. C1, C2 and C3 the phases of establishment of LWUA's GDB for Water Districts are illustrated.

NWRC'S GROUNDWATER DATA BANK

As previously mentioned, NWRC is a national agency entrusted with the task of co-ordinating, planning and assessment of water resources utilization in the Philippines.

With respect to groundwater, the NWRC role is to collect and store all available groundwater data and to use these data in the assessment of groundwater potential in the Philippines.

In 1979, NWRC embarked on the UNDP supported programme which among other things, was supposed to provide assistance for systemization of well records and reorganization of the existing groundwater data bank. During the period 1979-1980 the different forms for groundwater data collection were prepared:

- Scheme for Location of Borehole with Manual for completion of the scheme.
- Borehole Entry Books
- Drillers Well Log Record Sheet
- Pumping Test Data Sheet
- Well Log Records Sheet for cyclogram mapping with Manual for completion of the Sheet.
- Different Check Lists for the control of data collection.
- Water Quality Data Sheet with Manual for completion of the Sheet.

The organizational aspects of NWRC GDB were considered and the procedures for collection of new and existing borehole data were outlined as shown in Fig. C4 and C5. The training was provided to NWRC regarding collection and processing groundwater data into GDB.

The equipment for manipulation of maps and data is proposed as illustrated in Fig. C6.

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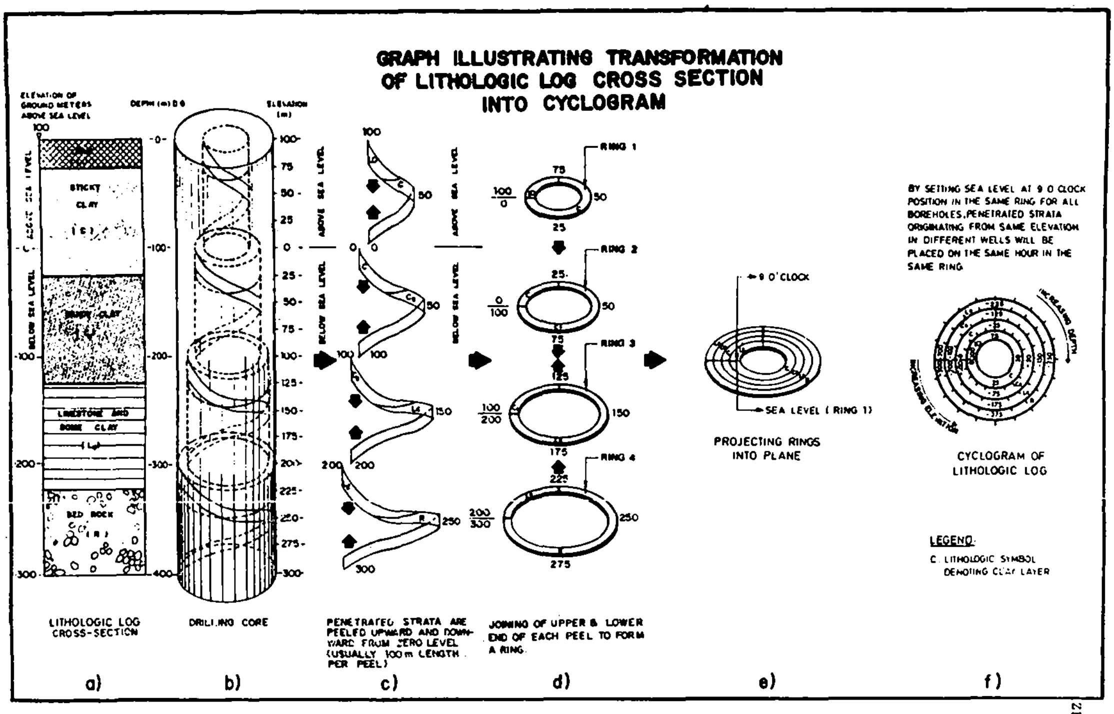

Fig. B1 Transformation of lithologic log into cyclogram.

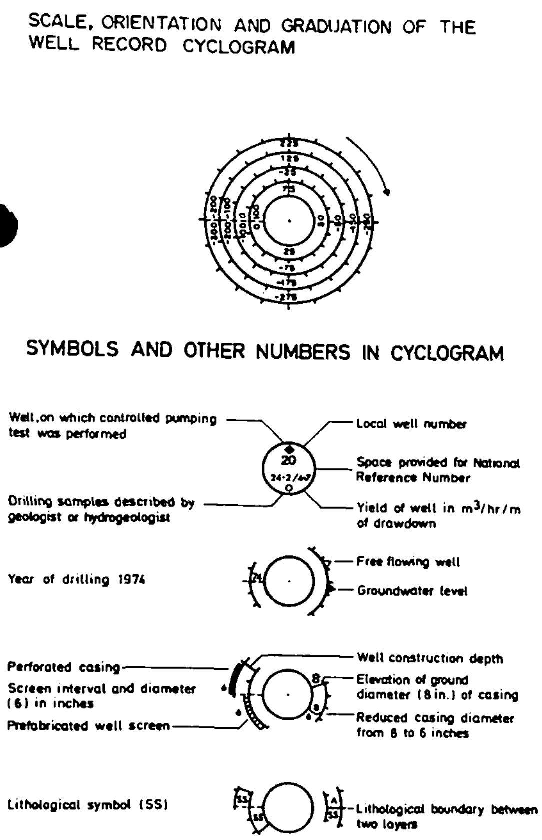

Fig. B2 Well Record Cyclogram (size 1:1)

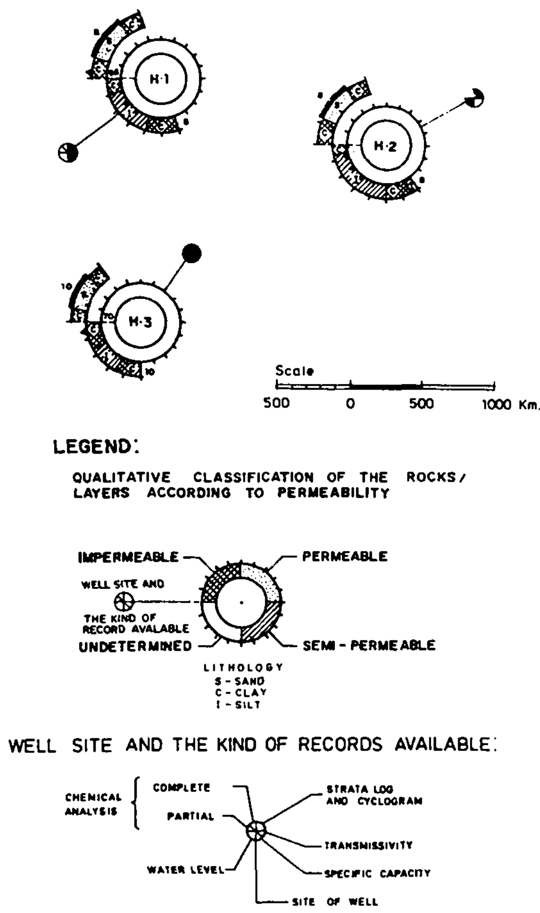

Fig. B3 Hypothetical arrangement of cyclograms to illustrate correlation of layers.

which may or may not be related to its age.

Consequently, in hydrogeological interpretation, the penetrated strata are classified into permeable and less permeable layers from which the ability of different layers to store water and form an aquifer is evaluated.

In the hydrogeological interpretation of the cyclogram map the three colours are usually applied to distinguish among permeable (blue colour) semi-permeable (violet colour) and impermeable (brown colour) strata or rocks. In some instances when it is necessary to make distinction between different lithological units and/or degree of consolidation, this is done by colouring the permeable strata with different colours.

Correlation of Strata by using Cyclogram Map

To correlate layers means to determine the strata having similar characteristics e.g. lithology, permeability etc. and to extrapolate the vertical and horizontal extent of such strata in the space in between two or more boreholes.

To illustrate the correlation from cyclogram to cyclogram a hypothetical arrangement of the three cyclograms is shown in Fig. B3. By setting a common zero level to the same (interior) ring the penetrated strata originating from the same elevation in different wells will be placed on the same hour in the same circular ring. Hence, the correlation of layers/rocks from well to well becomes possible by looking into the same section (hour) of each ring. As it could be seen in Fig. B3 the permeable layers (indicating an aquifer) are situated approximately in the same section of the same outer ring (ring No. 3) which indicates the presence of aquifer at almost the same level in all three boreholes. Similarly, the spatial (vertical and horizontal) distribution of the surrounding layers could easily be visualized.

It should be mentioned here that the correlation of strata from cyclogram to cyclogram is not done by drawing the lines of any kind. The correlation (extrapolation) is done in mind only and after some practice such a correlation becomes an easy matter. However, it should be pointed out that the horizontal or slightly inclined layers can be directly correlated in the cyclogram map. If the layers are inclined and the boreholes are spaced widely or there are the substantial changes in the vertical position of the same layer, due to tectonic movements, the meaningful correlation of the horizontal extent of such layers could be difficult if not impossible.

Ultimately, when the correlation of layers is not possible, due to above mentioned reasons, the cyclogram map should be used as a Base Map, showing penetrated strata in three dimensions and other numerical and technical data of individual wells only, i.e. the cyclogram map becomes a graphical Data Bank.

When mapping borehole data by cyclogram method, it is also important to remember that the elevation of ground level at the well site should be determined as correct as possible. Otherwise the layers in cyclogram will be vertically displaced and the correlation of layers in between cyclograms will to a certain degree become inaccurate.

Advantages of Cyclogram Mapping Technique

By using the cyclogram mapping technique, many advantages are gained in relation to other borehole mapping techniques.

The most important advantage is to have all pertinent records from wells and boreholes presented on a one single map which is easy to use both by groundwater specialists and other persons concerned with development and management of groundwater resources.

Furthermore, for all wells/boreholes presented on the map the selection reference level is always same (9 o'clock in one of the rings). This provides an immediate spatial correlation of (horizontal) layers from borehole to borehole without drawing correlation lines, which means that data from new well(s)/borehole(s) may just be added to the map without changing (redrafting) the earlier data. A progressive build-up of data base such as this is much easier to follow than if cross sections or block diagrams are used.

Aside from presenting both the technical data and penetrated layers on a single map, uncoloured cyclogram map is a Base Map of low degree of interpretation. The original data, on which subsequent interpretation is based, can always be easily changed when new data provide better information. For instance, if in an area in which the drillers' logs are available only, a new borehole is drilled and a better lithostratigraphic classification and/or description of the layers is available, the the previous hydrogeological interpretation of layers in the surrounding boreholes may be changed by changing the colours only. However, the original data are still shown underneath.

Many useful judgments of criteria relating to the quality of drillers' logs against geological interpretation can be worked out this way. Once the cyclogram map is prepared and interpreted it can advantageously be used to select the potential site for drilling well(s)/borehole(s) with a greater confidence. Furthermore, the map provides an immediate insight into the composition of aquifers in the area and may advantageously be used as an aid in the analysis of pumping test data (especially with regard to the aquifer boundaries) and eventually for management, control and protection of groundwater resources. The cyclogram map of the well records is actually a mini Groundwater Data Bank presented on a single map.

(B) PART TWO

CYCLOGRAM METHOD FOR MAPPING OF BOREHOLE/WELL RECORDS

INTRODUCTION

The purpose of mapping of borehole (well) data is to illustrate strata logs and other relevant data about boreholes/wells in such a way that the type of aquifer(s), lithological composition of penetrated strata, the boundary conditions as well as aquifer hydraulic parameters can easily be defined.

The well records provide a source of data for construction of the different (hydrogeological) maps and graphs from which the above mentioned properties are determined. Among these maps the map showing location of boreholes, position of penetrated strata and other records from existing wells and boreholes is essential for the proper interpretation of groundwater conditions in an area. Such a map is called a Base Map of well records.

There are many ways of graphical illustration of well records. The vertical and horizontal extent of penetrated strata is usually illustrated in the cross sections or some sort of three-dimensional diagrams (block, panel diagrams, etc.). However, the mentioned types of graphs have a drawback because each time a new information from a borehole is gathered, the diagrams have to be redrawn and reinterpreted. Furthermore, when a large number of boreholes have to be presented, many diagrams are needed and the presentation easily becomes confusing.

By using the cyclogram mapping technique, the principles of which are given in the following sections, the above mentioned disadvantages are avoided.

CYCLOGRAM METHOD

Well Record Cyclogram — Explanation

The log of penetrated strata as obtained from the driller is usually presented in the form of cross section (Fig. B1a). To facilitate understanding of the cyclogram form for presentation of well records the transformation of borehole's cross section log into a cyclogram log is illustrated in Fig. B1b-f. The figure is self-explanatory but it could be added that by transferring the lithologic log's cross section into a cyclogram the third dimension (depth) is added to a two dimensional co-ordinate system without projecting the third dimension into space, as it is usually done in other mapping techniques.

The explanation of well record cyclogram is illustrated in Fig. B2. As shown in Fig. B2 the cyclogram consists of a number of concentric circular rings. It is decided that each ring embraces 100 meters of penetrated strata. If greater detail is required the length per ring may be reduced to suit such requirement (e.g. for the geotechnical borings). In many instances where groundwater is a major source, the terrain is relatively flat and wells/boreholes usually do not exceed the depths of 400 meters. Hence, a total of 4 rings (representing 400 meters length) would be sufficient for illustration of penetrated strata. For wells (boreholes) penetrating more than 400 m below ground additional rings would be added to accomodate the presentation of all strata from such wells (boreholes).

In the cyclogram shown in Fig. B2 the reference level (sea level) is selected at 9 o'clock in the interior ring. Hence, the interior ring shows counterclockwise increasing elevations from zero to 100 m above sea level. Clockwise, the elevation decreases (depth increases) to sea level at 9 o'clock again. The elevations below sea level are indicated in the three outer rings which show the elevations from sea level down to 300 m below sea level. It is mentioned here that any other level could be selected in any of the rings as a reference level. However, it is required that the selected reference level is the same for all boreholes presented in the same cyclogram map.

To complete a well record cyclogram other data (symbols and numbers) are added into or around cyclogram. As seen in Fig. B2 the composition of penetrated strata is described by symbols (letters) added into sections of the cyclogram. Furthermore, the parameters such as well discharge, drawdown, groundwater level, dimensions and intervals of screen and casing, year of drilling, adopted well numbering system and other relevant data are indicated by symbols or digits.

The cyclogram method for mapping borehole data is probably the only method available for showing location of wells and boreholes, three-dimensional illustration of penetrated strata and presentation of other technical and hydrologic data from wells, all on one single map. Consequently, the cyclogram map is a Base Map of well records which is essential for proper interpretation of groundwater conditions in an area.

Hydrogeological Interpretation of Cyclogram Map

As shown in Fig. B2 the lithological composition of penetrated strata is indicated by different symbols (letters).

The lithostratigraphic as well as hydrogeological interpretation of strata can be illustrated by colouring (or shading) the different sections of the cyclogram. However, it should be appreciated that the above two mentioned interpretations are fundamentally different. Namely, while the lithostratigraphic interpretation is mainly concerned with the determination of age of layers or rocks the essence of the hydrogeological interpretation is the determination of permeability of the rock or layer

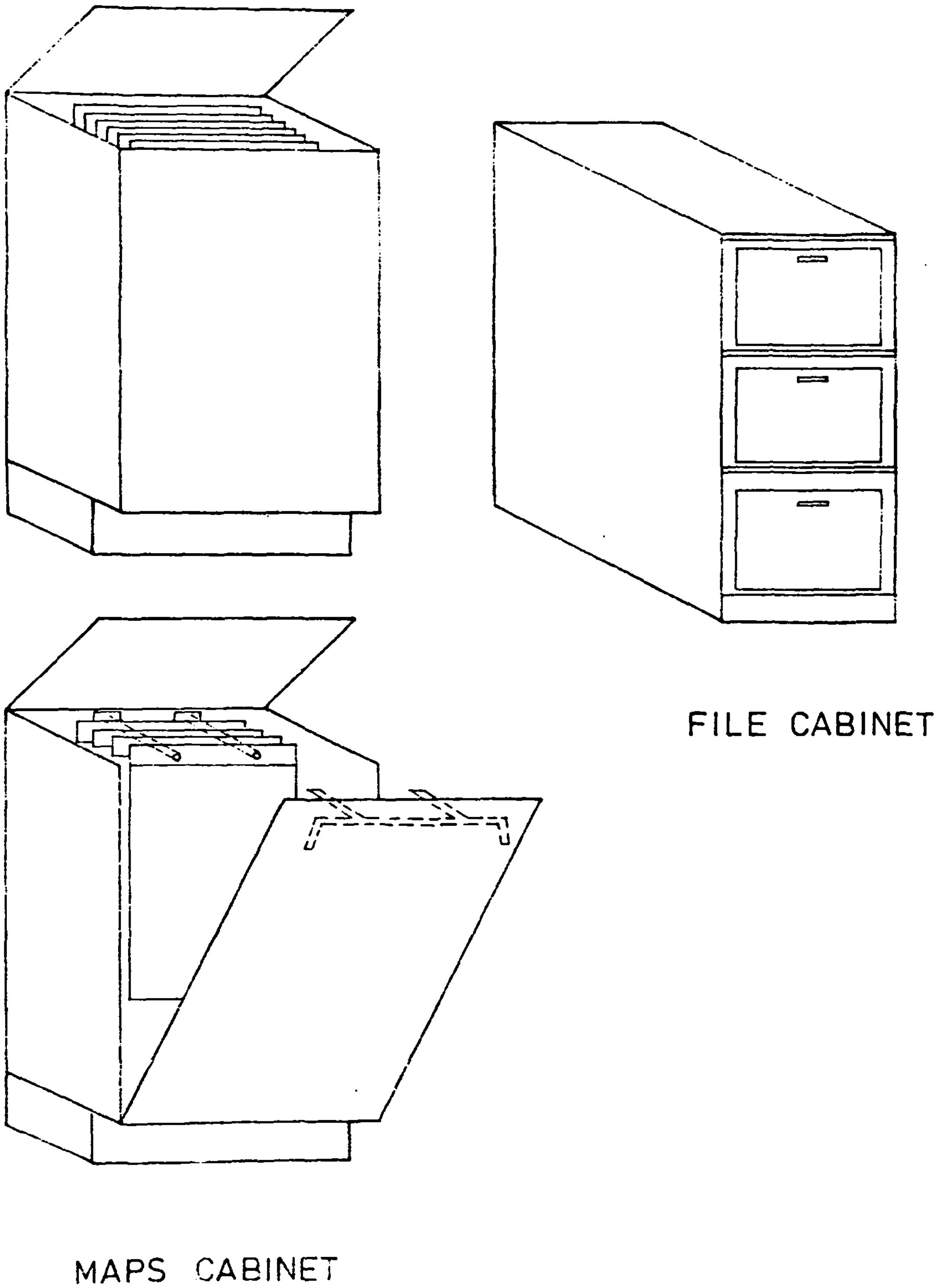

Fig. A8 Office Equipment for Well Records and Base Maps.

	Map No.
	Sheet No.
	Scale

DATA COLLECTION CHECKLIST

Well No.	0	100	200	300	400	500	600	700	800	900
1										
2										
3										
4	X									
5										
6										
7										
8										
9										
10	X									
11										
12										
13										
14	X									
15										
16										
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44										
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47										
48										
49										
50										

Well No.	0	100	200	300	400	500	600	700	800	900
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52										
53										
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100										

- Technical Data
- Geological Data
- Chemical Data
- Ground Level Determined
- Collection of Technical and/or Geological Data not Possible

Fig. A7 Data Collection Check List.

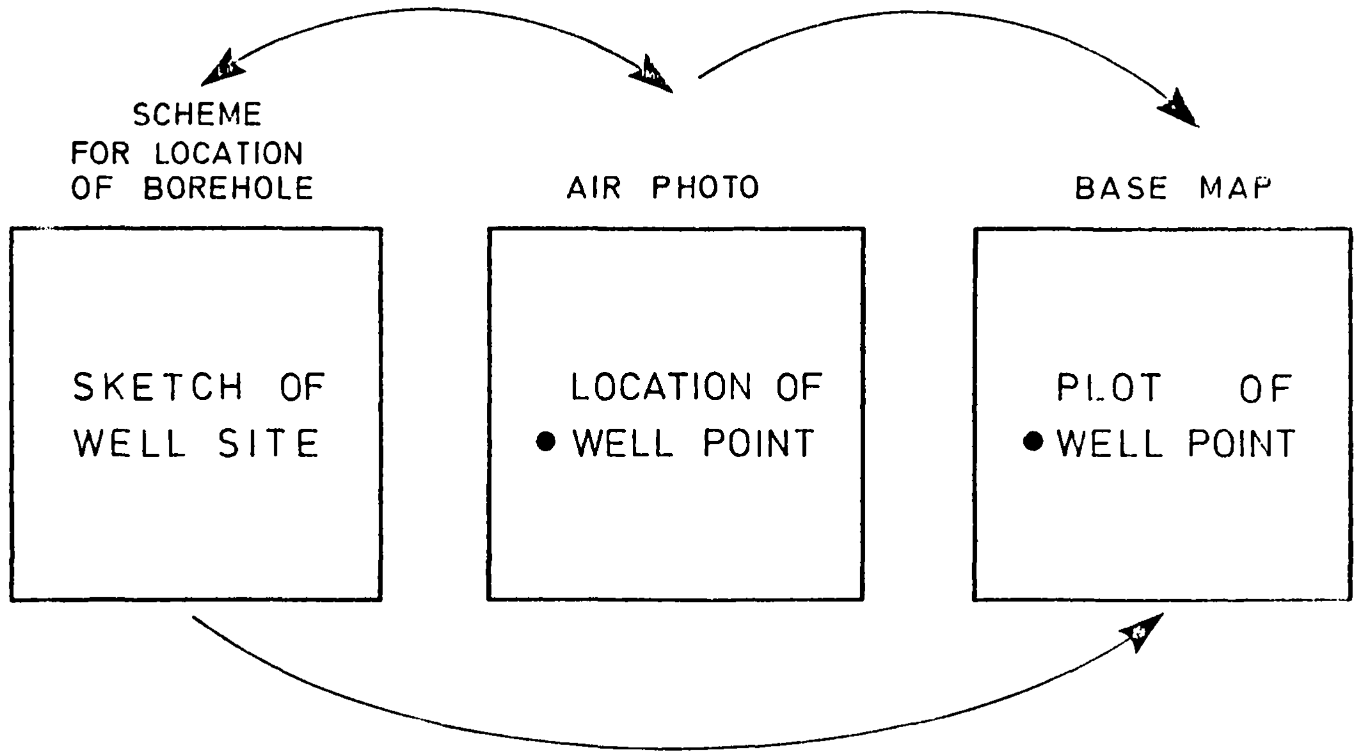


Fig. A6 Transfer of Well Point to the Base Map.

REPUBLIC OF THE PHILIPPINES
NATIONAL WATER RESOURCES COUNCIL
8TH FLOOR, NIA BUILDING, E. DELOS SANTOS AVE. Q.C.

SCHEME FOR LOCATION OF BOREHOLE

A Water Permit Application No.	B Drilling Permit No.	C National Ref. No.
D Water Permit No.	E Region Number 4	F Basin No. & Name

1a Present Owner Name and Address BATANGAS CITY WD, BATANGAS CITY

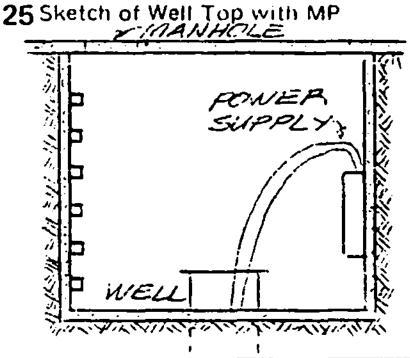
1b Owners Number WO2 — 2 Former Owner

3 Local Number 3261.2 — 4 Agency LWUA — 5 Water Use Association BATANGAS CITY

DATA	a TRANSFERRED FROM WELL LOG		b ON SITE GATHERED DATA	
6 Drilling Completed Date/By	a		b	
7 Casing Diameter	Metric	English	Metric	English
	a	14 I	b	
8 Drilling Depth	a 189		b	
9 Water Level Depth B.G.R.	a 42.89		b	
10 Discharge	a 136.3		b	
11 Drawdown	a		b	
12 Type of Screen and Perforation	a		b	

18 Possibilities for Measuring Water Level	(YES) NO
19 Ground Elevation 64	M A/B M.S.L.
20 Measuring Point (MP)	M A/B G.R.
21 MP Elev.	M A/B M.S.L.
22 Water Level Depth	M A/B M.P.
23 Water Level Elev.	M A/B M.S.L.
24 Water Level	S D

25 Sketch of Well Top with MP



13 Information Written By/Date 25041979 MM

14 Type/HP of Pump

15 Water Analysis P C B

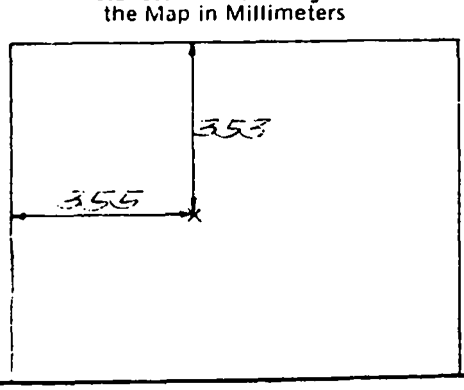
16 Use

17 Information Given by

26 Remarks

27 Well Point — Map No. 3261.52 — Scale: 1:12500

Distances from the Edges of the Map in Millimeters



28 Coordinates

Long.

Lat.

30 Located Date 20041979

By MM

29 Sketch of Well Site ALANGILAN

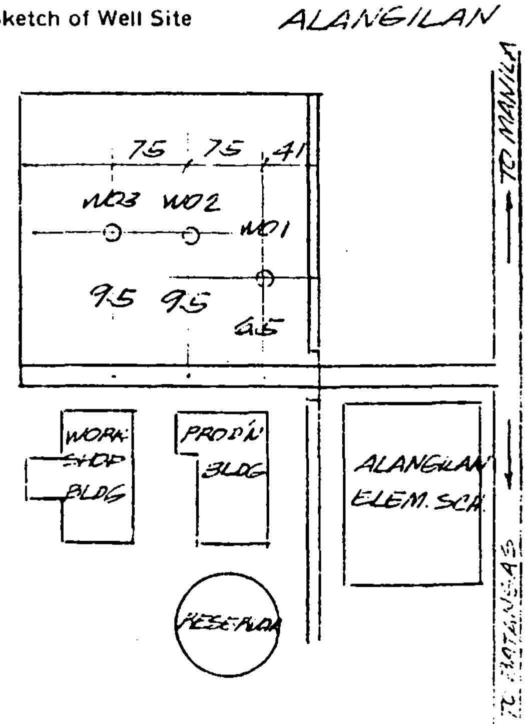


Fig. A5b Scheme for location of Borehole (completed)

	SCHEME FOR LOCATION OF BOREHOLE

1a Present Owner Name and Address

1b Owners Number | 2 Former Owner

3 Local Number | 4 Agency | 5 Water Use Association

DATA	a TRANSFERRED FROM WELL LOG		b ON SITE GATHERED DATA	
6 Drilling Completed Date/By	a		b	
7 Casing Diameter	Metric	English	Metric	English
	a		b	
8 Drilling Depth	a		b	
9 Water Level Depth B.GR.	a		b	
10 Discharge	a		b	
11 Drawdown	a		b	
12 Type of Screen and Perforation	a		b	
13 Information Written By/Date			14 Type/HP of Pump	
26 Remarks			15 Water Analysis P C B	
			16 Use	
			17 Information Given by	

18 Possibilities for Measuring Water Level		
	YES	NO
19 Ground Elevation	M A/B	M.S.L.
20 Measuring Point (MP)	M A/B	G.R.
21 MP Elev.	M A/B	M.S.L.
22 Water Level Depth	M A/B	M.P.
23 Water Level Elev.	M A/B	M.S.L.
24 Water Level	S	D
25 Sketch of Well Top with MP		

27 Well Point

Map No. ____________

Scale: ____________

Distances from the Edges of the Map in Millimeters

29 Sketch of Well Site

28 Coordinates

Long

Lat.

30 Located Date

By

Fig. A5a Scheme for location of Borehole.

	Map No.
	Sheet No.
	Scale

LOCATION CHECKLIST

Well No.	0	100	200	300	400	500	600	700	800	900
1										
2										
3										
4	/									
5										
6										
7										
8										
9										
10	X									
11										
12										
13										
14	X									
15										
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Well No.	0	100	200	300	400	500	600	700	800	900
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- First information about borehole is received and a number is given
- Borehole is located
- Approximate Location Only
- Borehole site is plotted on map
- Approximate (plot) position on map only
- Ground level is fixed and inserted
- Location impossible

Fig. A4 Location Check List

Borehole No. INDEX/SHEET No. WELL No.	Date of Entry Day, Month, Year	Address Street No., District City
e.g. 3750.1	e.g. 12th Jan. 1979	Tac-an, Talamban, Cebu City e.g.

Example

Borehole No., Entry Book

Name	Address Street No., District City	Number INDEX/SHEET No. Well No.
e.g. Son Miguel Corp.	e.g. Tac-an, Talamban Cebu City	e.g. 3750.1

Borehole Address, Entry Book

Fig. A3 Examples of Borehole No. and Boreholes Address Entry Books.

REFERENCES:

Z. Haman, 1978 : Importance of Groundwater Data Bank for Optimum Planning of Groundwater Development. Proceedings Philippine Institute of Civil Engineers, Conference Cebu, Philippines.

Z. Haman, 1979 : Groundwater Data Bank. System Approach and Case History. UNDP/NWRC open file report. Manila/New York.

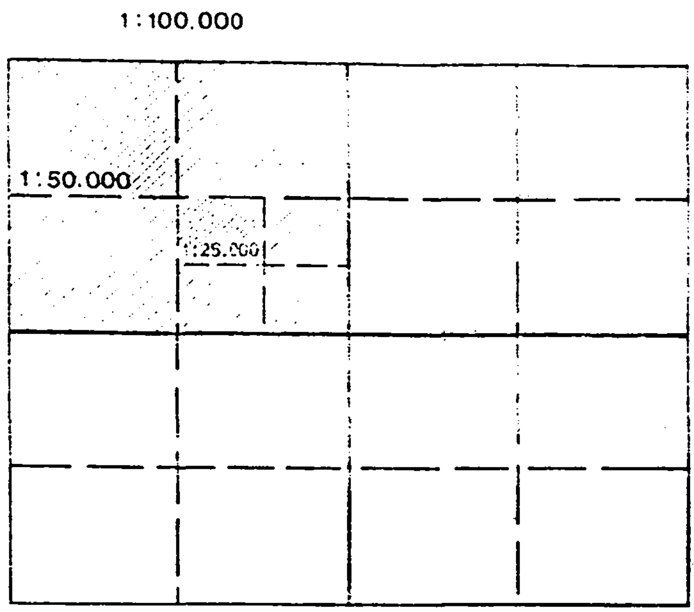
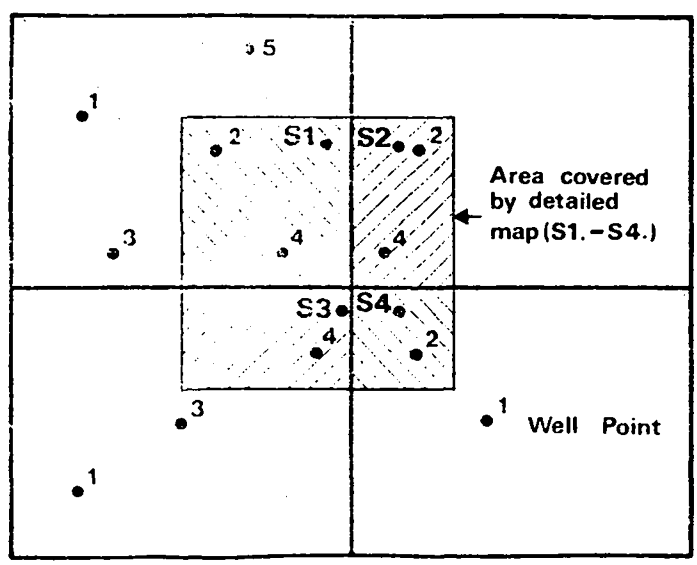


Fig. A1 System of Maps from which the most detailed map covering the whole of the country is selected as a Base Map (1:25.000 in this case).

BASE MAPS, SCALE 1:25.000
INDEX / SHEETS No 1. INDEX / SHEETS No 2.



INDEX / SHEETS No 3. INDEX / SHEETS No 4.

Fig. A2 Well numbering system = INDEX/ SHEET No followed by Well Point No from the respective map.

of boreholes.

- Airial photos (if available) could often supplement or even replace the topographic map for location of boreholes as they provide better orientation in the field.
- Compass for orientation in the field.
- Altimeter to determine the elevation of ground at a well site, especially if aerial photos are used for location of boreholes.
- Water level probe to measure the depth to water level.
- Stopwatch to measure discharge.
- Assorted tools to open pipes, locks etc.

The students from the local schools could easily be motivated and trained to assist with location work. Normally, their knowledge of the local conditions would greatly facilitate and speed up the location work.

Location Check List (Fig. A4)

Location Check List is used to plan the progress of location work for wells/boreholes already recorded into the Borehole Entry Books but not yet located. The Location Check List will also serve for the preliminary numbering of wells/boreholes which are found in the field during location work, but have not yet been recorded in the Boreholes Entry Books. Combined, the Borehole Entry Books and the Location Check List serve to avoid the possibility of one well/borehole being assigned two different numbers or two wells/boreholes having the same number.

Scheme for Location of Borehole (Fig. A5a-b)

Normally, the Scheme for Location of Borehole is utilized first in the office, to transfer relevant data about the well into a scheme. Thereafter, the scheme is used by a location team in the field, to sketch the exact location of a well in relation to the existing permanent structures and to record some other data gathered on site during the location work.

The manual, explaining step by step the procedures for completion of the Scheme for Location of Borehole is provided.

Transfer of a well point from the Scheme for Location of Borehole to the Base Map (Fig. A6)

After completion of location work in the field, the Scheme for Location of Borehole is again used in the office to plot the well point onto the Base Map.

After a well is plotted X, Y, Z coordinates (either relative to the edges of the map or the true geographic coordinates) will be read out and recorded into the scheme.

To find a particular well point on the Base Map two types of coordinates may be used:

a) Well point is located at the recorded distances as measured from the edges of the respective map.
b) Well point is located at the intersection of recorded, geographic X, Y, Z coordinates.

By knowing the Index Number of the Base Map, *on which a particular well is plotted*, and X, Y, Z coordinates of the well site (either universal or related to the edges of the particular map), it is easy to find a well point on the Base Map. When well records are computerized, X, Y, Z geographic coordinates could be uniformly used for the computer plot of well points and for the identification of the particular well.

Data Collection Check List (Fig. A7)

Data Collection Check List complements the Location Check List and serves to obtain quick information about the available well records such as well logs, technical data, hydraulic properties data, etc. for located wells. From the check list the wells, having sufficient data, are selected for further analysis and preparation of the special hydrogeologic maps.

Furthermore, by using this check list it is determined if the kind of and the amount of data from the located wells is sufficient for the interpretation or additional field investigation for collection of new data is required.

Safe-keeping of Well Records (Fig. A8)

The Schemes for Location of Borehiles, Entry Books, Check Lists, Base Maps as well as all other collected well records should be kept in such a way that they are safe against fire, damage or estrangement. However, to facilitate the daily work of retrieval and storage of data the records, maps etc. should be easily accesible. An example of the standardized office equipment for the safekeeping of well records, etc., is illustrated in Fig. A8.

Presentation of Well Records

Groundwater Data Banks should not be established because of data banks only. True enough, the well records buried in the cabinets, storage rooms etc. are a priceless treasure, but to get a full use of this data they must be presented in a way which enables their use by groundwater specialists and other persons concerned with development of groundwater resources alike. A method which provides for such a presentation is a cyclogram method which will be explained in Part Two of this paper.

Experience has shown that in introducing such a system the excessive and unlawful withdrawal and in many instances a mismanagement of the groundwater resources is efficiently prevented.

Well Records Section

In order to organize an efficient Groundwater Data Bank the Well Records Section must be established with the purpose of receiving, filing, keeping, administrating, and releasing data pertaining to groundwater. The staff experienced in collection of data, location of wells and processing of collected data should be made available for day to day operation of the well Records Section.

Base Map (Fig. Al)

To illustrate the geographical distribution of (located) wells and boreholes these must be plotted on an appropriate topographic map. The map which should be selected for a countrywide plotting of the well points must show sufficient detail and should cover the whole of the country. Such a system of maps is called the Base Map. The selected scale of the Base Map should provide a possibility for an accurate plotting of the location of the well site in relation to its actual topographic position. Furthermore, it should be possible to plot a comparatively large number of the well points on any Base Map.

In the areas in which there are many wells, a map showing a greater detail will usually be required. However, it should be kept in mind that all detailed maps must be indexed in such a way that they become a subpart of the respective Base Map. (See also Fig. 2A).

It follows from above that it is important to decide as early as possible which map system and scale is to be used for the Base Map, because all subsequent numbering of wells and selection of a more detailed map will have to be related to the selected Base Map System.

Numbering of Wells/Boreholes (Fig. A2)

Each Base Map provides the space for a relatively great number of wells and boreholes in a shown area. For numbering of wells, INDEX No. (Sheet no.) of the Base Map followed by point and consecutive numbering of well and boreholes points could be proposed. For example, X.1 means that this is the Well No. 1 on the Base Map No. X.

It could be argued here that for the numbering of wells X, Y, Z coordinates should be used only because they uniquely determine the geographic position of the well site. However, it should be kept in mind that X, Y, Z coordinates can only be given when the well site is exactly located and the well point transferred, (plotted) onto the Base Map. Therefore, another well numbering system (e.g. such as suggested above) should be used for the identification of wells during location work. In the later stages, when the well site is located and plotted on the Base Map, or other related maps, X, Y, Z geographic coordinates could be determined and recorded into the Scheme for Location of Borehole.

Borehole Entry Books (Fig. A3)

When the information about a well/borehole (either new or existing) has reached the Well Record Section it should immediately be given a number next to the last number recorded on the respective Base Map. The numbering of well/boreholes is facilitated by using the Borehole Entry Books.

Two different books for each Base Map should be made available:

- Book for recording of the number of the well/borehole.
- Book for recording of the well/borehole owner's name in alphabetic order.

The examples of entries are illustrated in Fig. A3.

The above mentioned books also serve as a cross reference file for the quick identification of well/borehole in the Groundwater Data Bank.

Location of Wells/Boreholes

Location Work

Each well/borehole recorded into the Groundwater Data Bank must be located. To locate a borehole means to find a well/borehole in the field, to sketch its excat position in the area and to plot this position on an appropriate map.

For the purpose of location of a borehole, a special checklist and scheme are provided. (Fig. A4, A5a-b).

Location work is a perpetual activity both in the office and in the field. The location work consists of numbering of wells/boreholes received from different sources, planning of the field work, training of well survey teams, work in the office and in the field, processing of collected information and plotting of well points on the Base Map.

For location of well/borehole site in the field the surveying team should have the following equipment:

- Measuring tape, length minimum 50 m, to measure distances from the well point to the permanent structures (at right angles)
- Topographic map of adequate scale to locate the exact geographic position of well point in the terrain and to read out elevation of ground at the well site. The map showing greater detail should be preferred for location

ceeds the rate of replenishment and the mining of groundwater occurs.

As a consequence of such a development the water level declines continuously, the cost of pumping and the drilling depth increases and the groundwater quality may be adversely affected. Very often such a development can be attributed to the unsatisfactory drilling practices and an erroneous overall planning of the groundwater development. This results in a rather bad publicity for the groundwater source and in the worst case leads to the negligent utilisation of this otherwise reliable source of water.

There are numerous examples all over the world of this trend in groundwater development.

As a rule, better the aquifer, longer the period before a quantitative evaluation of this important resource is undertaken. When this becomes necessary, the development (of an aquifer) is usually in a very advanced stage and the situation is often out of control.

Due to the fact that groundwater is usually a stable resource both quantitatively and qualitatively, with the predictable variations in water levels, a systematic collection of data and an evaluation of aquifer potential for withdrawal is rarely attempted in the beginning of groundwater development. Without a reliable data the initial conditions of water level, which are very important for the quantitative appraisal of aquifer potential, are either lost or obliterated. This prevents the rational analysis of the past history of aquifer development and impedes the exact future projections.

It may be asked why this is so and could this not have been prevented. The answer to this question is very simple.

If the systematic reporting of data from boreholes and wells is initiated at an early stage, and development of groundwater reservoir is progressively followed through these records, the deleterious consequences of such a development may be foreseen well in advance and effectively prevented.

Experience has shown that usually the government agencies have the potential to appreciate the necessity for coordinated planning of water resources and to initiate a systematic collection of groundwater data and the establishment of a comprehensive Groundwater Data Bank.

GROUNDWATER DATA BANK SYSTEM

General

In the following sections the basic elements of Groundwater Data Bank system, which may be adjusted and expanded to take care of the special local requirements, are explained and illustrated.

Groundwater Data Bank system may be used for the following purposes:

a) To provide a progressive build-up of knowledge on groundwater conditions in an area,
b) To provide a reliable background for water resources master planning and selection of the most promising areas for the groundwater resources development,
c) To optimise the number of wells, drilling depth and well construction,
d) To administer and control the groundwater abstraction,
e) To control the groundwater quality,
f) To protect the groundwater from pollution,
g) To provide a better management of the groundwater resources.

In order to achieve these objectives the procedures for coordinated collection of groundwater data must be established and promulgated among the different users of groundwater.

Legislation Aspects

An efficient collection of groundwater data must be supported by an adequate legislation.

This is an essential requirement for building up of the Groundwater Data Bank, provided it is obeyed continuously.

After a borehole is drilled (and well constructed) the owner, or his authorized representative, is required to forward the strata logs and other numerical data from the wells to a controlling body which considers the appropriation of waters and issues the Water Right or Water Permit for groundwater abstraction.

An efficient management of groundwater resources and control of withdrawal is achieved by giving the right to withdraw a specified amount of groundwater from aquifer in the areas to the approved applicants.

To obtain such Water Permit (Water Right) the applicant should provide the following data:

a) Strata and other logs (e.g. geophysical).
b) Records of water level encountered during drilling.
c) Construction characteristics of well casing and screen.
d) Pumping test data, preferably with the prognosis of water level decline as a function of time and distance for desired withdrawal.
e) Desired withdrawal (which must be well documented).
f) Water quality data.

From these data, the relevant authorities will be able to assess properly the consequences of groundwater withdrawal and henceforth the Water Permit (Water Right) for pumping of an appropriate volume of groundwater could be issued. The Water Permit implies that the prescribed withdrawal must not be exceeded without the legal consequences to the applicant.

ESTABLISHMENT OF GROUNDWATER DATA BANKS IN THE PHILIPPINES

by ZIVONIMIR HAMAN

Kampsax-Kruger
Consulting Engineers,
Denmark

(A) PART ONE SYSTEM APPROACH

INTRODUCTION

General

Investigation of possibilities for groundwater withdrawal should be always be considered in any water resources development, even though surface water may be available. The quality of groundwater is always nearly constant, chemically and physically, and temperature fluctuations are small. Groundwater withdrawn from properly located, designed and constructed wells will often be clear and clean and can easily be protected against pollution. Because of this characteristic of groundwater, the need for treatment is minimized and in some cases entirely eliminated. Lower investment cost is realized because development requires shorter pipelines since groundwater supplies are usually available nearby. Furthermore, huge underground storage eliminates the need for large surface reservoirs.

In any large scale groundwater development a thorough and systematic assessment must be made of the available groundwater resources. In addition, the future water needs must be estimated in order to determine how much water should be supplied from groundwater.

The results of all groundwater studies must be presented in a usable form.

To achieve these objectives, the establishment of a reliable groundwater data bank, a continuous collection of new data and the processing of data on a regular basis is the most important requirement in the planning of groundwater development.

Once established the groundwater data bank contributes to optimisation of the development budgets, it enhances the knowledge about aquifers in a particular area and provides a reliable guidance for drillers as to the depth of drilling, and well construction thus often reducing the overall cost of drilling.

Finally, the groundwater data bank provides a reliable background for establishment of rules and regulations for environmental protection of this precious resource. Therefore, the importance of establishment of groundwater data bank can never be too strongly emphasized.

Some Consequences of Uncontrolled Groundwater Development.

Whenever there is available groundwater near a population centre, wells are drilled (in most cases by enterprising individuals or organisations) to abstract groundwater for water supply purposes. Reporting of data to a central body capable of appreciating the significance of proper development of groundwater has seldom been practiced under such conditions. The analysis of depth of drilling and the rate of decline of groundwater level reveals a following regular pattern of events as a consequence of uncontrolled groundwater abstraction in such areas.

In the beginning few wells are drilled (often not penetrating the whole thickness of the aquifer) and development of the aquifer begins. More wells are added as time goes by and withdrawal from the aquifer gradually increases. As a consequence of this, the cone of influence, created by pumping, extends and deepens proportionally to the magnitude of withdrawal. Depending on the yielding characteristics and the size of the aquifer in question the total groundwater abstraction is usually smaller than the total recharge for quite a period. If it stays this way the withdrawal from aquifer would remain below its rate of replenishment and the decline of groundwater level would eventually cease.

However, in uncontrolled development of an aquifer, more often than not, the rate of withdrawal reaches the point in time when withdrawal ex-have been cooperating with the NWWA (National Water Well Association) in the United States, have attended meetings there, and in this way a transfer of technology is taking place.

PEOPLE PROBLEMS

The loss of experienced drillers to the Middle East has been noted. Some contractors have increased the salary of their workers as successful counter offers.

Logistical support of the crews in the field is a problem that is related to a slow cashflow. The combination of factors then cause further problems at the rig. Long periods of down time result in caving, excessive penetration of the water-bearing zones with drilling mud, and accumulation of excessive mud on the walls that make it difficult to remove during development.

Site acquisition is a problem because people do not want to sell land in the urban areas. However, once a rig begins operating at some of the densely populated areas, noise sometimes causes adverse reactions from the local population, particularly during 72-hour pumping tests when a generator must be operated throughout the nights. The assistance of the Barangay Captains have been sought to assist at such times.

Early in the project the performance of the Contractors working for MWSS was evaluated. For 30 wells for which there were records, it required an average of 138 days to complete wells. Of this time, 83 days were working days and 55 days were waiting for supplies, repairs, and other reasons. Contractors have been on sites of more than a year, having one problem after another.

To counteract the slowness a bonus has been offered for wells completed in less than 90 days, and in the short time that this rule has been in effect it appears to be an effective way to speed completions.

RESULTS OF PROGRAM

The changes that have been made in specifications and procedures appear to be improving the yield of wells and shortening the overall time of construction. In the past few months bonuses have been paid on 4 wells constructed in less than 90 days. With respect to well yield, for any particular area the yield of wells completed in the past year appears to equal or exceed that of wells drilled in earlier times. During August to October of this year five wells were completed, ranging in depth from 176 m to 305 m (580 to 1,000 feet). They were test pumped at rates of 12 lps to 36 lps (190 gpm to 572 gpm) and had specific capacities ranging from 0.8 lps/m to 4.88 lps/m (3.88 gpm/ft to 23.6 gpm/ft). This is an improvement over results obtained a year ago.

terial deposits;

- failure of the gravel pack allowing the invasion of fine material which reduces the permeability of the gravel pack; and
- rupture of the screen or casing allowing sand to enter and to block part of the screen section of the well.

In any event, the first step is to carry out routine redevelopment of the well by pumping and backwashing. If this fails or only partially restores the efficiency, the well may be acidized to remove carbonate encrustants from the screen and gravel pack, or subjected to more violent procedures for removing corrosion products or redeveloping the gravel pack. These may include surging and swabbing, jetting, or shooting selected sections with primacord. Only two wells have been rehabilitated under this project to correct quality problems because all older MWSS wells were rehabilitated about 3 years ago under another program, and also because no production-well-monitoring program has been in effect to indicate which wells require rehabilitation. It may be noted, however, that most of the problems of well failure derive from improper design, construction or development of wells.

Two wells were rehabilitated to correct water quality problems encountered during their construction. The results were as follows:

- the water from a 186 meters (610 feet) deep well contained excessive chloride, 1,600 mgl. Using a specially designed packer the various screen levels were isolated, pumped and chemical analysis made. Finally the bottom 40 meters (130 feet) of casing and screens were cement grouted. The final chloride content was an acceptable 160 mgl. and the well was put into service;
- a 150 meters (492 feet) deep well yielded water having 3.5 mgl dissolved iron. Using the same techniques of isolation of zones, pumping, and chemical analyses, data indicated the highest iron content water as the lower section of the well. The lower 55 meters (181 feet) of the well was cement grouted, and the iron content was 1.5 mgl, higher than recommended by standards, but not injurious to health. Use of the water was accepted by residents of the barangay.

DRILLING PROBLEMS

Problems during the drilling and construction of wells may be categorized as physical, technological, and people related.

PHYSICAL PROBLEMS

The physical problems relate to rock characteristics. The marine sediments along Manila Bay and in some places in the Central Luzon Valley consist of sand, silt, clay and shell. Many of the sand beds cave if mud is not controlled. Some marine clay beds are plastic and intrude into the bore hole, grabbing and holding pipe, tools, and equipment placed in the hole.

Recemented volcanic ash beds at some places are resistant to penetration by the drill bit, so much as that they are mistaken for basalt. Most of these have been encountered in the eastern part of the GMA.

Sand and tuff beds have caused some contractors series problems with lost circulation, and at times they have been known to drill blind for 20 to 100 feet.

Salt water is encountered in shallow aquifers within 1 to 3 kilometers of the bay, and below 180 m (600 feet) in parts of the Marikina Valley. Such beds must be identified and the casing grouted. Dissolved iron also has been a minor problem in a few wells.

TECHNOLOGICAL PROBLEMS

Problems in technology are caused by many factors, including isolation of the Philippines, the cost of importing new equipment and spare parts, the substitution of inferior replacement parts, and lack of regular and frequent communication with the water well industry in other countries.

Contractor experience difficulty in purchasing new equipment, even though much of the existing equipment is more than 30 years old. Government agencies have acquired new and modern rigs under various types of foreign aid loans and grants, to use on irrigation and water supply projects.

The locally mined bentonite is lacking in calcium and therefore is not as high quality as that which must be imported.

The common practices of using irregular shaped torch-cut slots in pipe and a gravel pack of too large size has been eliminated in the MWSS well drilling program.

The problem of bacteria in water from wells is caused by their introduction during the drilling and incomplete clean out during development. The temperature of ground water in the Philippine is nearly ideal for the culture of bacteria. More rigid requirements have been instituted to clean out and sterilize wells.

Fishing for lost tools is a problem caused by still another problem, the inexperience of many of the crews that have replaced the men hired in the Middle East. The drilling community in the Philippines has lost many of its most experienced drillers to companies in the Middle East, and drillers having lesser experience have taken over.

The drilling community of the Philippines, through their organization known as WELDAPHIL, ther require that development be carried out largely by surging and bailing, and completed by overpumping, and also provide for the carrying out of a step-drawdown pumping test to evaluate the efficiency of the well, and to confirm that development is complete.

Irrespective to any other factor, the most important feature of the design of a given well is the casing and screen schedule. This is designed on the basis of the lithologic log which is compiled during the drilling of pilot bore, and borehole geophysical logs which are made in the pilot bore. To provide the most reliable and comprehensive data for the design of the casing schedule additional equipment was procured to facilitate and enhance the basic data collection studies.

To improve the descriptions of drilling cuttings the field geologists were furnished with 10-power hand lenses for well-head studies, and a 20-300 power binocular microscope was procured for more detailed description carried out in the office.

For the borehole geophysical studies, the Johnson Keck, hand-portable, shot hole electric logger in service with MWSS was replaced by an improved version of the same model. This is a manually operated logger which produces point determinations of self-potential, resistivity (long or short normal) to a maximum depth of 300 meters. It is fully portable and thus is especially useful to logging wells situated in sites inaccessible to a truck mounted logger. For a more complete profile of subsurface conditions a Logmaster truck-mounted, compound logger was procured.

The compound logger automatically records the following logs to a maximum depth of 600 m:

- self potential;
- resistivity, 16 inch and 64 inch normal;
- gamma ray;
- temperature;
- fluid conductivity;
- flow meter; and
- caliper.

WELL AND AQUIFER TESTING

The main constraints in planning ground water development in the GMA are the lack of reliable hydraulic data both on well performance and efficiency which are needed to guide well design and well development, and on the hydraulic properties of the rocks which are needed to guide the siting of wells and well fields, and the formulation of ground water development and conservation programs. The only practicable sources of the data required to evaluate wells and aquifers in the GMA are pumping in test wells. There are many kinds of pumping tests reflecting various levels of sophistication, but all features as their central objective the determination of the relationship between the discharge of a well, and the resulting drawdown of water-level.

MWSS pumping test program is limited to discharge-drawdown type tests which involve only the collection of water-level data from the pumped well. Such test yield reliable values for transmissivity which is the most important aquifer hydraulic constant for planning purposes, and also, the most difficult to estimate from hydrogeologic inferences. A reasonably reliable value of the transmissivity of the aquifer in the immediate vicinity of a well can be obtained by analysis of water-level data from a constant-rate drawdown test. Somewhat less reliable values of transmissivity are obtained from data for step-drawdown and specific capacity tests. Notwithstanding the differences in accuracy between the methods, with a sufficient density of data from any method, or from a mix of the methods, the yield characteristics of an aquifer can be estimated with acceptable accuracy for planning purposes.

Reliable data on well performance for the selection of pumps and motors also are obtained from constant rate pumping tests. The drawdown can be projected for an extended period of pumping and the results used to estimate the pumping lift to be expected in future years during the service lives of the equipment.

The efficiency of wells can be determined from step-drawdown tests which differ from constant rate drawdown test only in that the rate of discharge is varied during the test.

Accordingly, two tests are routinely carried out on all Project wells as part of the construction works:

- 24-hour step-drawdown pumping tests to estimate the performance characteristics and efficiency of the wells; and
- 48-hour constant-rate drawdown pumping tests to determine the transmissivities of the aquifers.

In addition, specific capacity tests will be carried out as part of the well monitoring program, and also on wells for which no other kinds of pumping test data are available.

Specifications for carrying out the pumping tests, and detailed instructions for interpreting the results are given in a Manual on Pumping Tests.

The condition of a well in service is reflected by its specific capacity (discharge divided by drawdown) and by the sediment content of the water. A marked increase in the sand content or turbidity, or a marked decline in the specific capacity (10 percent or more between successive monitoring exercises) may be taken as indications that rehabilition is, or will be required. But the exact cause may not be obvious. Either effect may derive from several causes including:

- blocking of the screen openings by corrosion or encrustation products, or by bacprepared to set forth the technical specifications for all ground water development activities carried out for MWSS. The main provisions of the revised specifications are summarized in the following pages. Figures 2 and 3 show the design of a grouted well and a non-grouted well.

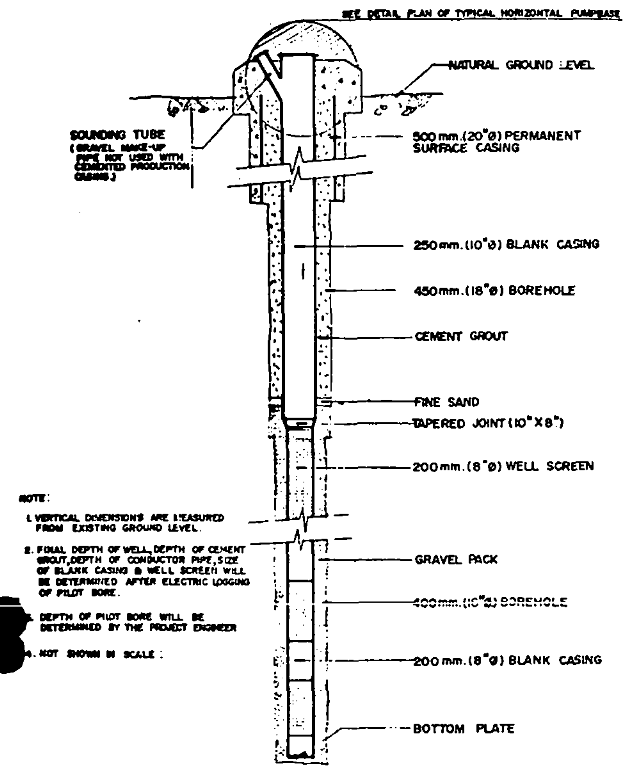


FIGURE 2 STANDARD WELL PLAN (FOR 10"Ø & 8"Ø CASING)
(GROUT-SEALED PRODUCTION CASING)

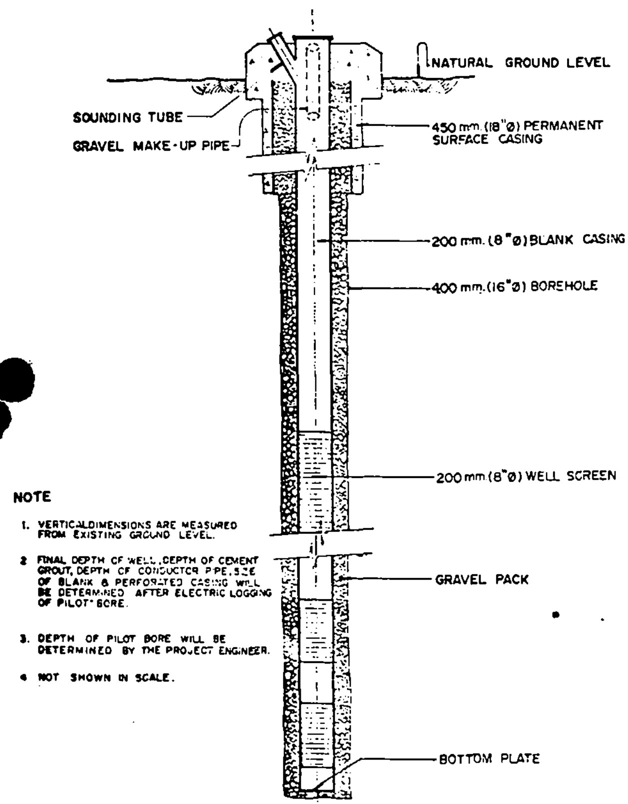


FIGURE 3 STANDARD WELL PLAN (FOR 8"Ø CASING)
(GRAVEL-PACKED TO SURFACE)

WELL DESIGN, CONSTRUCTION AND INSPECTION

Management of the well drilling program of MWSS was assumed by the Project in March 1980. Field inspections were carried out of all phases of well drilling and development, and on the basis of experience gained progressive modifications were made in the technical specifications for well design, construction and development, and in the procedures for supervision and inspection of work during construction. This led to the preparation of MWSS Ground Water Manual No. 1, Well Construction and Inspection which prescribes all standard well design and construction specifications, and supervision and inspection procedures governing the Project Ground Water Development Program.

The major revisions to the technical specifications are:

- more thorough and refined logging and sampling of drill cuttings so as to obtain properly logged samples for gradation analysis;
- more systematic and thorough inspection and supervision of works and record keeping;
- welding procedures are detailed;
- grouting procedures are detailed;
- mud control is specified;
- reaming, and installation of casing and gravel pack are required to be carried out in uninterrupted sequence;
- well screen or perforated casing with a minimum open area of 7 percent of the screen is required for better development and maximum efficiency;
- improved gravel management is required;
- controlled pumping tests are required; and
- effective sterilization procedures are required.

The revised specifications will result in more efficient and productive wells with longer service lives and greatly reduced requirements for maintenance and rehabilitation. From the standpoint of well performance the most important provisions are those dealing with screen design, well development, and the avoidance of delay during construction. Under previous practices operations commonly were suspended for extended periods after reaming of the borehole to its design depth and diameter while the contractor assembled casing, screen and gravel pack materials required for completion of the well. The mud-filled hole was susceptible to caving, and more important to the buildup of excessive mud cake, especially in the most productive zones. Subsequent well-development by undersized air compressors through screens with inadequate open area was rarely effective.

The revised specifications require the use of approved screens, and oblige the contractor to mobilize at the site all material and supplies required for completion of the well before starting reaming, so that reaming, and installation of the casing, screen and gravel pack can be carried out in one continuous operation. The specifications fur-

Valley, and through the tuffaceous rocks of greater Quezon City. We have used 15 percent of rainfall as recharge in our first ground-water model study.

The original ground water flow pattern was to discharge areas in Manila Bay and Laguna de Bay. This has been modified by the pumpage in 1981 at 622 mld (164 mgd) which created cones of depression. In 1981 fresh water still flows toward the GMA from the northeast, east and south. However, salt water is moving from Manila Bay on the west, and has caused the abandonment of countless wells during the last two decades.

WELL SITTING

The sitting of wells has been an important part of the well drilling and ground-water development program. It involves an estimation of the depth, water quality and yield of the well, the type and thickness of the rock materials to be penetrated by the drill and an estimate of their drilling characteristics.

The first criterion for the sitting of a production well is the need for water.

Once established, the next step in sitting procedure is to determine the most favorable general location of a well, or well field, and to estimate the number of wells which will be required and their respective depths. In the western, highly developed part of the GMA which is underlain by the largely alluvial sediments of the Manila Bay Aquifer System this is a largely routine process because the hydrogeology is known in sufficient detail to indicate the availability and quality of ground water with reasonable precision. The sitting of wells in known areas of salt-water encroachment results in detailed well inventories of the area to try and find all wells, but particularly those known to be abandoned because of contamination. Pockets or lenses of fresh water still exist at various depths between 15 m to 305 m (50 ft and 1,000 ft) in the encroached areas and wells have been developed successfully that yield from 0.63 to 6.0 lps (10 to 100 gpm). Two wells drilled recently near the MIA (Manila International Airport) found lenses of fresh water between 150 and 180 m of the land surface, and salty water above and below the fresh water.

Conditions are quite different in the eastern part of the GMA underlain by the Antipolo Plateau System and by volcanic and sedimentary rocks of Tertiary Age.

There are few subsurface data to indicate the occurrence of favorable conditions for the occurrence of ground water in these rocks. And the water-bearing properties of the Tertiary rocks are determined by secondary alteration of the bedrock by weathering processes, faulting and other tectonic features, and solution of carbonate rocks.

Accordingly, the sitting of wells in that terrane is based largely on the interpretation of the geologic inferences of unusual morphological features, or of lineation patterns on aerial photographs either of which may be the surface traces of favorable ground water drainage features. Future studies will test the use of satellite imagery, thermal infrared photography and other remote sensing techniques in the location of favorable water-bearing zones in the bedrock. Major and minor geologic structures are obvious on the satellite imagery, but cloud-free images are not common.

The last step in the sitting procedure is to select the precise location of the well (or wells). Apart from accessability the chief considerations are proximity of an existing pipeline and electric power, and the availability of the site. Availability of land in the GMA is most important, and it has been the main constraint on the progress of the drilling program. Ideally, the site is donated by the municipality which is being served, or is purchased from a willing seller. Where necessary MWSS can acquire land through condemnation proceedings, but this is a protracted and costly process, and impractical where there is an urgent need for water supply.

DRILLING METHODS AND SPECIFICATIONS

Water well drilling in the Philippines is mainly by mud rotary and percussion cable-tool methods. At least two contractors have air hammer, but none of the MWSS wells have been drilled by the method. Most of the rotary machines are capable of drilling to a depth of 300 meters; relatively few have a 600 meters capability, but no wells in the GMA are known to have drilled that deeply.

STANDARD SPECIFICATIONS FOR MWSS GROUND WATER DEVELOPMENT PROGRAM

Introduction

Review of the past records of construction and operation of MWSS wells, and experience with the construction of the carryover wells from the crash program which were absorbed by the Project, revealed the need for major changes in MWSS development and operations practices and procedures including:

- improved specifications for wells including the basic design, and construction and development procedures;
- more stringent and systematic supervision and inspection during construction and development of wells;
- more reliable and quantitative testing of wells; and
- systematic monitoring and maintenance of production wells.

All of these aspects have been dealt with in appropriate detail in technical manuals which were

Guadalupe Formation

The Quaternary Guadalupe Formation is composed of pyroclastic and sedimentary units which crop out along the central eastern side of the Marikina Valley and along the rolling hills west of Marikina fault. It includes a basalt member commonly referred to as the Alat Conglomerate which is exposed in the north near the boundary of Caloocan City "B" and Bulacan province. The Guadalupe Formation underlies the alluvium in the lower Marikina Valley and in the coastal area of Manila Bay.

Field mapping indicates that the formation consists of distinct lithologic units the extent of which cannot be definitely established owing to interfingering relationships. The basal Alat Conglomerate overlies Tertiary age volcanic and clastic rocks near Montalban. Agglomeratic tuff comprises the purely pyroclastic member which contributes little ground water except where thin lenses of volcanic cinder and pumice are intercalated with the tuff. Part of the Guadalupe Formation consists of sediments of volcanic rock reworked and deposited in streams, deltas and along shore in bays. These sands and conglomerates comprise the most productive water-bearing rocks in the GMA.

Few wells penetrate the entire Guadalupe Formation and its total thickness is unknown. The Alat Conglomerate is no more than 200 m thick. The pyroclastic and upper section of essentially sedimentary rocks may be 1,000 m or more thick.

ANTIPOLO PLATEAU AQUIFER SYSTEM

The Antipolo Plateau Aquifer System consist of rocks which are classified as part of the Guadalupe Formation, but which appear to be isolated from the Guadalupe rocks of the Manila Bay Aquifer System by fissure basalt along the bounding Cogeo fault of the east side of Marikina Valley. The fault and basalt appear to be an impediment to the movement of ground water. The Antipolo Plateau System encompasses only about 14 square kilometers. To the east of the bounding fault tuffaceous sedimentary rocks were deposited which form the present day Antipolo Plateau. The sedimentary rocks consist of volcanic tuffs interbedded with large, angular rock fragments, rounded cobbles and gravels, well sorted sands, and beds of silt and clay. These rocks are considered a coarse-grained facies of the Guadalupe Formation.

The three major lithologic units within the Guadalupe Formation indicate periods of volcanic eruptions followed by weathering, erosion and redeposition of pyroclastic materials, not unlike conditions in recent times. The erratic pattern of terrestrial and waterlaid sedimentation further compounds the already complex distribution of permeable and impermeable layers. Nevertheless, reworking and redeposition of normally tight pyroclastic rocks introduced better sorting of grain sizes and improved the porosity and permeability of the tuffaceous sediments. The water-bearing and water yielding characteristics of the Guadalupe Formation was later enhanced by the development of fractures associated with faulting.

VOLCANIC ROCKS

The volcanic rocks include basaltic and andesitic flows and related eruptive rocks exposed in the prominent ridges between Antipolo and San Mateo, Marikina. In the Lungsod Silangan area the volcanic rocks are covered by a thin cover of pyroclastic rocks.

Drilling through these rocks is particularly difficult except with the use of down-hole hammer equipment. Nevertheless, the volcanic rocks generally yield small to moderate supplies from highly-fractured zones. Well No. 5 in Cogeo yielded slightly more than 15 lps, the maximum yield of any well drilled locally in the volcanic rocks. These rocks yield an average of about 5 lps to a well. Wells drilled in massive and only slightly fractured rocks yield less than 1.0 lps.

UNDIFFERENTAITED TERTIARY SEDIMENTARY ROCKS

Folded clastic rocks and limestone of Tertiary age occur in the mountains north and east of Montalban and at the eastern edge of the Antipolo Plateau. These rocks consist of alternating sequences of shale, sandstone and limestone which have been gently folded into a series of north-trending anticlines and synclines.

The Tertiary Sedimentary Rocks have not supported any substantial ground water development other than shallow wells, and the magnitude of the ground water resources in these rocks are not known.

RAINFALL AND RECHARGE

Annual rainfall in the Manila area ranges upward from about 1,700 mm but varies from one place to another. In the mountains of Luzon and other islands rainfall exceeds 4,000 mm per year. At about a dry season extends from about January to May, a rainy season from May to October. Typhoons pass through from about May to late November. December and January are the cool months, when the temperature at Manila may drop to about 20°C.

Recharge of the aquifers takes place during the rainy season in the mountains and foothills that lie to the northeast, east and south. Data indicate that recharge also occurs from leakage from the Novaliches Reservoir in the northern part of GMA, directly into the alluvium of the Marikina

LOCATION

The old city of Manila was built in the area where the Pasig River entered Manila Bay. Less than 10 kilometers eastward is Laguna de Bay, a huge shallow fresh water lake. To the north is the Central Luzon Plain, to the south the upland that forms the west slope of the former mountain that was a volcano, and today is a huge crater occupied by Taal lake.

GEOLOGIC HISTORY

The Central Luzon Valley was formed during the late Mesozoic and early Cenozoic times as part of a north-south oriented eugeosyncline which was filled largely with tuffaceous and volcanic sediments, and minor chalk limestone. Orogenic action from late Cretaceous to the Middle Miocence resulted in the development in the east of the folded mountain range of the Sierra Madre and in the west of the folded and thrusted mountains of Zambales. By the end of Miocene time, the eugeosyncline had been reduced to an intermontane through similar in extent to the present Central Luzon Valley. With the rapid sedimentation during late Miocene a relatively constant depositional area was maintained through gradual subsidence, occasional orogenic isostatic movement and tectonic activities.

During the Quaternary and Recent times numerous eustatic changes in sea level resulted in the gradual emergence of the Central Luzon Valley and the change in depositional environment from marine to continental. The withdrawal of the sea from Central Luzon Valley was accompanied by uplifting associated with tectonic action. Manila Bay and Laguna de Bay, once a continuous arm of the sea, become separated and what now comprises the Greater Manila Area emerged from the sea.

The stratigraphy of the Greater Manila Area is given in Table 2. The older units occur on the lower slopes of Sierra Madre and far from the locus of urban development. The younger rocks, particularly the rocks of Pleistocene to Recent Age are the source of most of the ground water in the GMA and to the irrigation wells of the Central Luzon Valley to the north.

HYDROGEOLOGY

The Manila Bay Aquifer System

The Manila Bay Aquifer System consists of rocks and unconsolidated sediments of the Quaternary Alluvium and the underlying Guadalupe Formation. At most places in the subsurface the rocks are not distinguishable one from the other, and on a regional basis they function as a unified aquifer. Most wells obtaining water from this system are 300 meters deep or less.

Quaternary Alluvium

The Quaternary Alluvium is a significant part of the aquifer within the GMA particularly in the upper and lower Marikina Valley and the coastal areas around Manila Bay. The thickness of the alluvium is indeterminate over most of the GMA mainly because of the difficulty of distinguishing the alluvium from the underlying Guadalupe formation on the basis of lithologic criteria, especially the lithologic descriptions in driller's logs which are the main sources of subsurface data. The alluvium thickness varies from 100 m to more than 200 m along the Marikina Valley.

Along Manila Bay the alluvium is difficult to distinguish from the Guadalupe formation. Fossil shell fragments, leaves and wood are abundant in some of the units. Interpretation of drillers' and electric logs suggest that the Quaternary Alluvium may be more than 350 m thick near the shores of Manila Bay. Toward the inland areas the alluvium thins to a feather edge in the weathered pyroclastic rocks.

Lithologic logs of wells drilled near Manila Bay indicate sand aquifers under water-table conditions that are susceptible to sea water contamination. Most of the shallow domestic wells in those areas produce brackish water. The water-table aquifer in alluvial deposits occurs widely in the Bay area. Facies changes associated with deltaic deposits resulted in many variations in the vertical and lateral extent of the different lithologic units. Furthermore, individual lithologic units rarely attain great thickness. Sediments were deposited in a cyclic but uneven manner. What developed is a sequence of intercalated sand, silt and clay beds which thicken, thin, and pinch-out over short distances. The nature of such deposition produced local leaky-artesian aquifers which under the stress of heavy development behave hydraulically as a more or less unified water-table system.

Table 2. *Stratigraphy of Greater Manila Area*

Age	Caloocan-Quezon City Bulacan	Marikina Valley	Antipolo-Teresa
Recent and Quaternary	Alluvium-bay deposits	Alluvium	Allivium
Pleistocene	Guadalupe fm (3m-600m) Diliman tuff (500 m±) Alat Conglomerate (150 m±) Unconformity		Guadalupe fm Antipolo basalt-150 m±)
Middle Miocene	Madlum fm Diorite Unconformity		Madlum fm: Binangonan limestone Buenacop limestone Classic rocks
Lower Miocene	Angat fm (2,000 m)		Limestone 1,000 m Clastic rocks 300 m
Paleocene Oligocene	Maybangan fm Metavolcanic-meta-sedimentary rocks		

WELL DRILLING EXPERIENCE IN THE PHILIPPINES

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INTRODUCTION

A ground-water development program in the GMA (Greater Manila Area) was begun by MWSS (Metropolitan Waterworks and Sewerage System) in 1976 as a crash program of well rehabilitation and new well construction (Figure 1). The crash program was merged with the present project in March 1980 at which time MWSS was operating 84 wells. Funded by an IBRD loan, 50 wells are or will be drilled in the outlying areas of the GMA. Included in the project is a comprehensive study of ground-water conditions, site investigations and institutional building, because ground water will be a supplemental or primary source of water in parts of the GMA into the next century.

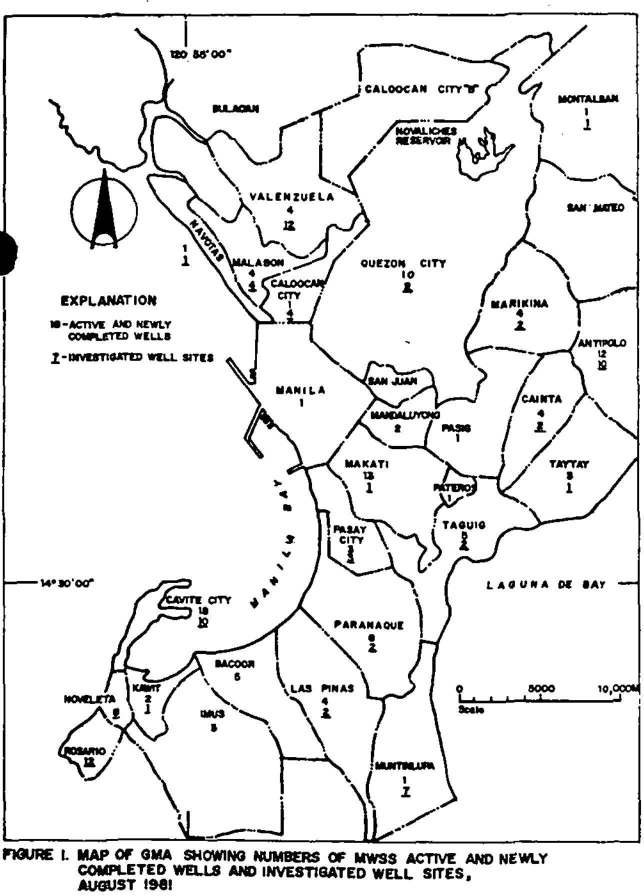


FIGURE 1. MAP OF GMA SHOWING NUMBERS OF MWSS ACTIVE AND NEWLY COMPLETED WELLS AND INVESTIGATED WELL SITES, AUGUST 1981

Between March 1980 and August 1981, 22 wells were completed that were drilled to depths of 175 m to 305 m (580 to 1,000 feet) tested at rates of 4.4 to 31.5 lps (70 to 500 gpm), and had specific capacities ranging from 0.13 to 2.4 lps/m (0.62 to 11.4 gpm/ft.), (Table 1).

In the coming two years 50 wells will be constructed under the IBRD project in the outlying areas, and other wells will be drilled in the GMA for supplemental supplies.

Table 1. Data for MWSS wells completed from March 1, 1980 to August 24, 1981

	Location	Date Started	Date Completed	Depth (ft)	SWL (ft)	PWL (ft)	Test Cap. (gpm)	Specific Cap. g/m/ft	REMARKS
1.	Valenzuela Marulas Elem. Sch.	11-23-79	3-2-80	1,000	419	471	82	1.58	
2.	Pasay City Marricaban	2-4-80	4-16-80	800	143	227	250	2.98	
3.	Bacoor, Cavite Niog	1-21-80	4-17-80	900	127	177	500	10	
4.	Navotas Merville Subd. Tanza	12-28-79	6-16-80	1,000	302	395	110	1.18	
5.	Malabon Niugan	4-8-80	6-22-80	1,000	67	256	299	1.06	
6.	Makati Poblacion Elem. Sch.	6-7-80	8-13-80	900	256	420	205	1.25	
7.	Parañaque MIA Complex Well No. 1	3-3-80	8-22-80	840	90	121	353	11.39	
8.	Parañaque MIA Complex Well No. 2	5-15-80	9-26-80	840	95	147	318	6.12	Chloride content exceeds standards
9.	Las Piñas Las Piñas Elem. Sch.	5-9-80	10-14-80	750	102	141	330	8.46	
10.	Manila Balut, Tondo	3-24-80	12-1-80	1,000	285	356	111	1.56	
11.	Taguig Upper Bicutan	12-5-79	1-25-81	700	190	285	220	2.32	
12.	Valezuela Isla	3-21-80	1-31-81	1,000	126	324	132	0.67	Chloride content exceeds standard
13.	Caloocan City Bagong Barrio	3-1-80	2-27-81	900	393	465	70	0.97	
14.	Quezon City (MSSD) Constitution Hill	12-5-80	3-8-81	1,000	170	274	183	1.76	
15.	Parañaque MIA Complex No. 4	10-19-80	3-13-81	1,000	147	348	367	1.83	
16.	Antipolo Sumulong Elem. Sch.	8-5-80	4-14-81	600	90	119	284	9.79	
17.	Parañaque MIA Complex No. 3	11-18-80	4-23-81	810	153	255	326	3.20	
18.	Malabon Dampalit	3-4-81	6-24-81	1,000	213	338	140	1.12	
19.	Parañaque San Dionisio (Sucat Road //3)	1-30-81	7-9-81	580	100	282	180	0.98	
20.	Valenzuela T. de Leon	3-23-81	7-21-81	1,000	266	450	115	0.62	
21.	Taguig Signal Village I Upper Bicutan	5-4-81	8-10-81	580	108	206	380	3.88	
22.	Malabon Santolan	2-21-81	8-22-81	1,000	324	366	125	2.98	

Well drilling in the GMA probably is typical of drilling in most parts of the Philippines in terms of hydrogeologic environment and climate, technological and people problems, and these will be discussed, along with some of the solutions and recommendations made to improve the technology.

However, when the water utility's facilities are severely under-utilized or when there is a big selling campaign, the selling function may be assigned to a more specialized and skillful group. In either case, field efforts must always be complemented by a responsive attitude at the utility's offices. Lastly, it should be mentioned that supervision and motivation of personnel who have personal contact with the utility's publics and markets must be given special attention. Their feelings about their own organization will be reflected in the service that they render to such publics and markets.

IV. *Incentives* – are defined as something of financial value added to an offer to encourage some overt behavioral response. They alter the perceived price of an offer in an effort to overcome the market's resistance, indifference or inability to avail of the utility's service. The free service connection offered by the Cagayan de Oro City Water District to households that wanted a 1/2" service connection is a typical incentive given to enable low income households to avail of the utility's service. Other utiliites offer a 10% discount for prompt payment of water bills, while still others provide for a 10% penalty for late payment – a negative (punishing) incentive.

V. *Atmospherics* – is the designing of buying, consuming or interaction environments in a manner calculated to produce specific cognitive and/or emotional effects on the target market or public. Atmospherics arise as a consideration when markets or publics come into contact with the utility's personnel and physical setting. The dress of the personnel and the physical setting emit visual and other cues that are very telling about the utility. These cues lead to inferences about the utility's efficiency, stability and concern for the particular market or public. Therefore, thought should be given to how the atmosphere of their establishment can promote the desired relationship.[5]

[1]Boulding, Kenneth – A primer on Social Dynamics (New York: Free Press, 1970)

[2]Kotler, Philip – Marketing for Non-Profit Organizations

[3]Kotler, Philip – Marketing for Non-Profit Organizations

[4]Kotler, Philip – Marketing for Non-Profit Organizations

[5]Kotler, Philip – Marketing for Non-Profit Organizations

as more of the establishments in the listed categories were connected to the District's water supply system, it would probably have been cheaper and easier to include them in handbills and leaflets than to amend or change the bulletin board. Lastly, handbills and leaflets would have provided greater flexibility since the quantities printed could easily have been increased to provide for distribution at the docks and bus stations. Of course the disadvantages of this medium of advertisement are:

a. A lot of people may just throw the handbills away thus causing waste and littering; and

b. Manhours of District employees may be required to distribute the handbills.

II. *Publicity* –

This refers to the achievement of news coverage in the press. In contrast to advertising, it is not paid for by the organization. Niether does it appear to be sponsored. The appeal of publicity to many organizations is that it is "free advertising." Actually however, publicity is far from free because special skills are required to write good publicity and to "reach" the press. Good publicists therefore cost money. Publicity has three qualities that work in its favor:

A. It may have higher veracity than advertising because it appears to be normal news and not sponsored information;

B. It tends to catch people off guard who might otherwise actively avoid salesmen and advertisements; and

C. It has a high potential for dramatization in that it arouses attention to a particular information whcih is provided in the guise of a noteworthy event.

On the negative side, the sponsoring utility has less control over the content of the final publicity in contrast with its total control over the content of a paid advertisement.

In deciding to use publicity as a promotional tool, the utility must:

1. Define the objectives of the publicity effort. This involves the identification of the target markets or publics, the definition of the specific target variable which the publicity is intended to influence (e.g. – awareness, knowledge, interest or desire) and the determination of the time frame for the publicity effort – i.e., whether its aim is to create a single news item, a short campaign, or a long educational effort.

2. Search for and develop "publicity ideas" that will achieve the desired effects. For instance, publicity concerning the inauguration of a utility's treatment plant could be an excellent occasion to dramatize the utility's concern for water quality. If the ribbon cutting ceremony could be undertaken by a local health official together with a representative of the lending institution or donor that provided part of the money to build the treatment plant, the news coverage of the event could plug in information that will also satisfy the lender's or donor's objectives and desires.

3. Lastly, the utility must plan for these events in terms of specific media involvement. The face to face events must be arranged along with their leveraged treatment in newspapers, magazines, radio and television. All this takes careful planning in order to achieve the effect of apparent spontaneity.

III. *Personal Contact* –

Personal Contact by the utility's staff with the target markets and publics – Some of these people are primarily engaged in selling while others are engaged in servicing. However, all of them create distinct impressions upon such markets and publics in the way they dress, speak and treat people. To effectively perform the personal contact function in a tuility, there is a need to:

A. Define the different roles that are to be played and set objectives for each of them. Personal contact can play three roles – selling, servicing and monitoring.

1. Personal contact serves a selling function to the extent that the utility's representatives are attempting to get more households or establishments to connect to its water supply system or to get bulk buyers of water (such as vessels) to increase their purchases. Personal selling can be a more effective tool than advertising in some situations. Whereas advertising is very public, indiscriminates, preformulated and impersonal, personal selling adds a human element to the relationship between the utility and the potential customer and allows a two-way dialogue and adjustment of interests to be worked out.

2. Servicing is the second function of personal contact. The service can take the form of consulting, informing or assisting customers or publics.

3. Monitoring is the third function of personal contact. The utility's personnel who deal with customers and publics are in a good position to sense grievances, new needs and developme ments that are not reflected in any statistics or reports.

All of the three foregoing functions may be assigned to one group (such as the meter readers).

case of the bulletin board displayed at the airport by the Cagayan de Oro City Water District, the target consumers consisted of transient visitors to Cagayan de Oro City as well as the affluent locals who patronized the types of establishments listed in the bulletin board.

2. Specifying the target effect sought – In the case of the bulletin board cited above, the effect sought was to create:

   a. Awareness of the quality of the water service rendered by the District;
   b. Interest in the establishments where such service is available;
   c. A desire to avail of such service; and
   d. Actual action by patronizing the establishments where such service is available.

3. Determination of the optimal target reach – Obviously, the District considered the optimal target reach to be limited to Airline passengers, otherwise a replica of the bulletin board could also have been displayed at the docking areas of the city's waterfront as well as at Bus stations. The District's staff must have felt that the types of establishments listed in the bulletin board catered only to the affluent class who could afford air travel.

B. Advertising Budget – This can be developed by estimating the number of exposures required to attain the desired target reach and then multiplying such number of exposures by the average cost of an advertising exposure in the type of media selected. In the case of Cagayn de Oro, the advertising media selected for Airline passengers was a bulletin board. It could also have been printed handbills, newspaper advertising or television exposure. Anyway – using the media selected, if the District had wanted to reach the passengers of vessels and buses, it would have had to spend for the cost of additional bulletin boards to be displayed at the docks and bus stations. Then, if the cost of one bulletin board is the cost of the exposure at one site, an increase in desired target reach could mean the multiplication of such cost by the number of bulletin boards required.

C. Copy Development – This is the message development process. It has three components, namely:

1. Theme Selection – Every advertisement or advertising campaign should be built on a central theme (also called motif, idea, appeal, or selling proposition) that brings about the desired effect on the market. Competing themes should be rated on:

   a. Desirability – A theme must say something desirable or interesting about the offering;

   b. Exclusiveness – It must suggest its distinctiveness from other offerings; and

   c. Believability – It must be stated in a believable manner.[4]

If the advertisment is visual, a decision must be made on illustration, typography, the use of space, size and color.

Going back to the bulletin board displayed by the water utility at the Airport of Cagayan de Oro City, perhaps the claim with respect to water quality could have been made more credible if a replica of the certificate issued by the Health Department of the City Government had been displayed either at the lower portion of the bulletin board or somewhere near it. Perhaps a lot more people could also have been enticed to read the message in the Advertisement if it had contained some pictorial attraction. As it is, the bulletin board contained merely words, although it did include the seal of the utility at the bottom. Had it included the picture of an attractive person drinking water inside one of the listed establishments, probably more people could have been drawn to read the message. After all, there is an initial need to attract attention before a message can be effectively communicated.

D. Media Selection – The major media categories are newspapers, magazines, handbills or leaflets, radio, television and outdoor advertising. The choice of the particular advertising medium or media, the type of copy to be featured and the desired target reach largely determines the size of the advertising budget. In the case of the Cagayan de Oro City Water District, radio and public meetings were heavily utilized to push the message concerning the quality of the water provided by the District. On the other hand, the listing of the District's Consumers utilized the Airport bulletin board as the medium of communication. This was probably a cheaper medium than newspaper or magazine advertising and probably it attained a greater target reach insofar as the target marekt (airline passengers) is concerned. Whether it was cheaper and more effective than handbills or leaflets is debatable. In the first place, the latter would have saved the people from the task of copying the list of establishments, which is a tedious chore. In the second place, The studies made by the District's staff indicated that while alternatives (a) and (b) would return the District's investment over a five year period, the amortization/installments of the customer when added to the expected average water bill would be affordable only by a small proportion of the low income households. In its passion for service to the community therefore, it made a bold decision by adopting the free service connection policy embodied in alternative (c).

6. Over all Results – The implementation of the District's Marketing strategy especially the portion cited in this paper has brought phenomenal results. When the District's Phase I Project was completed in 1978, it had a total of only 6,627 service connections. By the end of July 1981, it had increased this to 15,396 service connections representing a 232% increase in just a little over 32 months or an average increase of 7.25% per month. Perhaps a more objective appraisal of the Districts marketing performance can be gleaned from a comparison between the actual and the projected increases in service connections contained in the Feasibility Study for the District's Phase I Project. The Feasibility Study conducted by the Joint Venture of a local and an American consulting firm estimated that in 1980 the District would generate an additional 1,000 new service connections. In that year the District actually generated 3,140 new service connections, surpassing the target by 314%. As of this writing, the District still continues to generate more service connections, averaging roughly 274 new connections per month. Apparently, the limiting factor is not the lack of applications for new connections but the availability of District personnel and equipment to install the new connections as fast as the applications come in. As its marketing program turns out to be a whooping success, the District has of course picked up a number of laurels along the way. With his proverbial Midas touch, General Manager Ernie San Juan is rapidly turning Cagayan de Oro City Water District into one of the country's most affluent water utilities outside of Metro Manila. As a gesture that represents its commitment to public service, the District has wisely utilized its burgeoning affluence in the extension of its distribution mains, thus enabling it to serve more and more of the City's population while at the same time generating even greater affluence for the District. Since the completion of its Phase I Project in 1978 up to 1980, the District has added a total of 15,560 lineal meters of transmission and distribution lines to its water supply system. This has been financed solely from internally generated funds and the District considers this as an integral part of its marketing program – to make its resources work for the benefit of the consumer. In the latest awards for outstanding Water Districts of 1980 held at Cebu City in August 1981, the District won the top honors in the Veterans Category as it scored heavily in marketing performance and internally financed physical facilities development. Because of its outstanding performance and proven institutional capability, it is also one of the first Districts scheduled for implementation of its Phase II Expansion and Improvement Program under joint financing by the Local Water Utilities Administration and the Asian Development Bank. But perhaps the most important though unrecognized achievement of the District is the fact that it has gained the acceptance, respect and loyalty of the vast majority of the people of Cagayan de Oro City. For those of us in the Local Water Utilities Administration who have had the privilege of working with the officials and staff of the District there is a rewarding sense of satisfaction in seeing a true partner in progress that has really arrived.

COMMUNICATION AND PROMOTIONS

The objectives of the Public Information and Marketing Programs of Water Utilities will never be attained unless they can direct effective communications and promotions to their respective markets and publics. While communication is an all embracing term that signifies the transfer of a message or idea from a sender to a receiver, promotion is a special form of communication whose primary task is persuasion. The various promotional tools may be classified into:

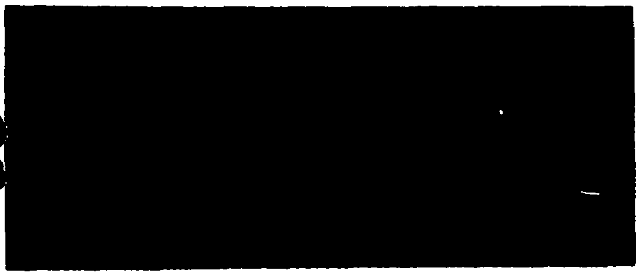
I. *Advertising* –

This is any paid form of non-personal presentation and promotion of ideas, goods or services by an identified sponsor. The bulletin board displayed at the airport of Cagayan de Oro City by the C.D.O. Water District was a form of advertising, since it was a pronouncement concerning the establishments that were patronizing the services offered by the District. To some degree, it contained a testimonial to the quality of the service rendered by the District. In deciding to use advertising, the utility must develop its advertising objectives, budget and message and select the appropriate media for its offerings.

A. *Objectives* – establishing the advertising objectives involves:

1. Identification of the target consumer – In the

were causing such ailments. As the sales volumes and occupancy levels in the listed establishments started to rise, the District was convinced that the people (transients and locals) accepted that the water supplied by the District was indeed potable. The act of copying the list of establishments in the bulletin board also convinced Ernie that the customers' desire for safe water made them patronize the listed establishments. So at this point, he delivered the "Coup de grace" by ordering a number of stickers to be displayed prominently at the entrance of hotels, inns, motels, lodging houses and clubs and cocktail lounges served by the District. These stickers indicated that the establishments on whose entrance they were displayed were served by the Districts' water supply system. A copy of the sticker is shown below.



A smiling Mr. San Juan said – "I'll save them (the customers) the trouble of copying from the bulletin board."

4. Results – A few weeks after the stickers were stuck on the entrances of the served establishments (or perhaps after declining sales were confirmed by financial statements of some non-connected establishments) the first representative of a non-connected establishment called on the District. In the ensuing months he was followed by others. They were prepared to discard or sell their pumping units to out of town buyers as soon as the District could install a service connection to their respective establishments. Of even greater importance to them was inclusion in the list at the airport bulletin board and acquisition of the District's sticker to be stuck at the entrance of their respective establishments. Over a five month period starting in February 1981 when this marketing campaign was launched, the number of connections for the categories specified in the bulletin board increased by 17%. Considering that these were the bigger establishments that could even afford to install their own pumping systems, the increase in total sales for these categories would probably be even more significant. As an added bonus, this marketing campaign even had spill-over effects on other types of business establishments as well as on the affluent and middle income households. The former, specially industrial establishments sought the connection as a means of improving their employees' health and morale and as a means of reducing employee absenteeism caused by water borne diseases. The latter either felt that they were just as entitled to potable water as the customers of their respective business establishments or they concluded that paying for the District's water was preferable to stomach disorders.

5. The low income market – after their success with business establishments and affluent and middle income households, the District turned its attention to the low income segment of their market. Since the process of connecting business establishments and high and middle income households to the water supply system was highly visible, the low income households were now completely aware that the respected segments of society accepted the benefits and advisability of connecting to the District's facilities. The District's staff who were campaigning for connections among low income households also discerned that the latter abhorred not only the inconvenience of queueing to fetch water at public standpipes and other sources but also the fact that such practices made their poverty more visible to the community. They were also convinced that the practice of carrying water in cans to their homes increased the risk of contamination and the fact that the cost of water to them (P.05/5 gal. can = P2.60/M^3) was more expensive than if they had a service connection with the District's system. Intuitively the District's staff also felt that since most of the local "Joneses" were now connected to the system there would be a natural desire for almost everyone to join the bandwagon. The problem however was that the low income households could not come up with the initial cost for the installation of a service connection (average = P400.00/connection). The District therefore evaluated the following alternatives:

a. The initial cost of installing a service connection to be amortized by the customer for a five year period at 9% interest per year;

b. Such cost to be paid in installments by the customer over a period of five years without interest; and

c. Such cost to be absorbed by the District for all 1/2" residential service connections not exceeding 30 meters from the nearest distribution main of the District.

their private pumping systems instead of connecting to the District's water supply system was a correct decision. He decided then that his problem was to find ways to make their "refusal to connect" detrimental to their respective businesses.

3. The marketing strategy – This focused on the customers of the target business establishments. In the words of Ernie – "the central idea is to make customers patronize the establishments that are connected to the District's water supply system and make the recalcitrants realize that they will face declining sales or lower occupancy levels if they persist in their refusal to connect to the District's System." Knowing that connected and non-connected establishments of the same types were catering to the same limited market, Mr. San Juan felt that a boost in the sales of connected establishments would mean declining sales on the part non-connected establishments. Intuitively, he also knew that nobody enjoys having stomach disorders or intestinal problems. He felt therefore that customers would shy away from establishments that caused such ailments and patronize those with better quality water if they had reasonable assurance that indeed the water supply in the latter was reasonably safe. His theory therefore was – if the vast majority of these establishment's customers could be enticed into patronizing the particular establishments that were connected to the District's water supply system, then there would be a tremendous pressure on the non-connected establishments to follow suit. "After all," he said "the customer is always right." Smiling, he rolled up his sleeves and told his staff – "Heretofore, we have been trying to sell service connections and water to these establishments. – Well, from now on, we'll play a different ball game. We will sell them "better business" and "higher sales." We will create a situation where being connected to our Water Supply System will be in the best interests of their respective businesses." Standing up, he continued – "I'll get them to connect to the District's System yet." Following the foregoing rationale, his strategy involved:

a. Providing that the water supplied by the District was potable – this was accomplished by a certificate from the Health Department of the City Government stating that their analysis of water samples extracted from different faucets drawing water from the District's water supply system was potable and free from harmful pollutants.

The existence of this certificate was emphasized in all radio programs where District officials were invited to participate. It was also given extensive publicity in the local papers and District officials displayed either the original or a xerox copy of such certificate at any public forum to which they were invited or to any group of people who would want to look at it.

b. Identification of the particular business establishments in the above cited categories which were connected to or serviced by the District's water supply system and reiterating that guests and visitors therein are "assured of drinking water which meets international standards is safety, potability, abundance and cleanliness" – This was done by means of a bulletin board posted at a strategic place at a strategic place at the Airport of Cagayan de Oro City, a photograph of which is shown below:

c. Observance of Transient visitor's reaction to the foregoing – The day following the posting of the bulletin board shown above, the District's observers were pleasantly surprised when visitors and even some local people were observed not only to be reading but even copying the list of establishments enumerated in the bulletin board. It seemed that either some people did not want to repeat their unfortunate experience with stomach disorders in Cagayan de Oro City or word had gotten around that the water in some establishments not served by the District

B. Market Orchestration – When dealing with business and institutional customers, adept Marketing practitioners often work on the customer's own market to exert pressure on the latter. This is specially effective when dealing with commercial customers described in market segment 2.a and follows the theory that Commerical customers are heavily influenced by what they perceive to be "in the best interests of their business."

Case Study – **THE CAGAYAN DE ORO CITY WATER DISTRICT**

1. Background – Cagayan de Oro City is a fair sized City in the southern portion of the Philippines. The water utility serving the city is the Cagayan de Oro City Water District. The District service area has its usual mix of affulent, middle income and poverty stricken households. Shortly after the completion of the District's Phase I Expansion and Improvement Project in 1978, the affluent and middle income groups were either connected to the District's Water Supply System or they operated their own private wells. On the other hand, most of the poorer households got their water either from public standpipes connected to the system or from their more affluent neighbors. Insofar as commercial and industrial establishments were concerned, those who operated their own pumping systems refused to connect to the District's system while those without such pumping systems readily connected. Before the District was created, the water supply system was operated by the City Government. Because of lack of adequate funds as well as institutional and environmental factors, the water supply system degenerated into a dilapidated state and at the time the District was created in October 1973, it had become woefully inadequate to service the City's growing requirements. Some households and many business establishments therefore drilled their own wells in their own backyards in order to provide for their own needs. The groundwater within the Core City is however contaminated by bacteriological as well as some chemical pollutants and is therefore not potable. While the District's pumping systems are more efficient than those operated by the business establishments and households, the burden of heavy debt service resulted in Water Rates that are more expensive than the direct cost of producing water from the wells of the business establishments and households. Since they considered their capital investments in water producing units as "sunk costs," these potential customers refused to connect to the District's water supply system. Being influenced by purely financial motives, their stock answer to the District's sales pitch was – "We will connect when it is time to scrap or discard our equipment." Since the average economic life of these equipment could be as long as ten years, the District had a problem. It had to tap this segment of its market if it was to attain viability.

2. Identification of the types of businesses that need large amounts of water and analysis of their operations and basic motivations or interest – Unfazed by the initial setback, Ernie San Juan, the District's General Manager, took a direct hand in the development of the marketing program. For a start he undertook a research on the type of business establishments that would require large amounts of water and should therefore be primary targets of the District's Marketing campaign for commerical establishments. He found out that these were:

   a. Hotels;
   b. Inns;
   c. Lodging houses;
   d. Motels; and
   e. Clubs and Cocktail Lounges (which also operated as Restaurants)

   Continuing his research into their operations, he discovered that those which were not connected to the District's water supply system invariably were pumping water within their own premises to their building's internal plumbing system to provide for their bathing, sanitary flushing and other cleaning requirements. Water for their own as well as their customer's drinking requirements were invariably drawn from a house (sometimes the owner's own house) or other source that draws water from the District's system. The operation would be technically perfect except that careless customers of the establishments often use the non-potable water from the tap for drinking purposes or are served such water by employees who are either overworked or just plain careless or lazy. Ernie knew that many transient visitors and even residents of the city had stomach or intestinal problems and disorders after drinking such non-potable water. He also knew that after such an unfortunate experience, tourists from Western Countries often stuck to bottled soft drinks or beer rather than drink water for the duration of their stay in Cagayan de Oro City. Analyzing this segment of his market, he concluded that as businessmen, their decisions were influenced by rational business motives – and indeed, from a strictly financial point of view, their decision to continue operating also afford the initial cost of a service connection.

2. The commercial and industrial establishments which need water for their business operations and which may be further subdivided into:

   a. The service establishments like hotels, restaurants, vessles, etc. which use water not only for their operations and the needs of their employees but actually make the same available for the cleaning and drinking requirements of their customers. To a large degree therefore, these types of establishments serve as a conduit through which the water is made available to their customers – who are the ultimate consumers. These establishments normally consume large amounts of water. The quality of the water that they make available to their customers can also be a big factor in the development of their business;

   b. Establishments which use water solely for the needs of their employees and operations but rarely make the same available to their customers. Fish markets and PVC pipe manufacturers would fall under this category. They also consume large amounts of water but water quality is not as critical to them as to the categories described in 2.a; and

   c. Establishments which use water solely for the needs of their employees. Hardware stroes, jewelry stores and banks would fall under this category. Their consumption of water is relatively insignificant.

3. Other institutional users of water which may be subdivided into:

   a. Government Offices which need water for the use of their employees and the public that deals with them. Depending upon the size of their staff, the public that deals with them and their efficiency in enforcing water conservation measures, these offices could also require fairly large amounts of water but quality is not as critical to them as to the categories described in 2.a; and

   b. Schools, hospitals and clinics which need water for their faculty and staff as well as for the drinking and cleaning requirements of their clientele (students and patients). These institutions also consume large amounts of water and quality is almost as critical to them as to the categories described in 2.a.

C. Setting up priorities – The establishment of priorities in the Utility's Marketing program is generally guided by its basic policies. If the attainment or maintenance of viability is a basic policy objective, then top priority will probably be given to potential customers in the business and institutional segments of the utility's market. These are basically influenced by rational or economic motives and are therefore easier to appeal to. Since they are large consumers who are probably charged a higher level of tariffs, the returns in terms of sales generated per unit of currency invested in the marketing campaign will also tend to be higher.

On the other hand, if the Utility's policy makers are more interested in tapping the household market or in any case, where the business and institutional market has been fully served, then top priority may be focused on the former and the formulation of the marketing program should follow this direction.

IV. *Formulation of the Marketing Program*

This is guided by the priorities established insofar as target market segments are concerned.

A. Design of offerings – These are done in terms of the target market's needs or motives and desires. Here the Utility's marketing unit can opt for either of the following basic approaches:

1. The "hard sell" where the Utility's salesman goes directly to the customers concerned and tries to convince them to connect to the Utility's water supply system, citing the advantages of such a move and the benefits to be derived therefrom by the customer. If the sales pitch has been properly planned, the salesman will focus on the customer's needs and desires rather than on his or the Utility's bias or tastes. A utility that adopts the "hard sell" would typically be using persistent salesmen who do not easily give up or take "no" for an answer. In the Philippines, the "hard sell" is personified by the proverbial encyclopedia salesman who will use every gimmick to get the customer's attention and upon gaining admission into the latter's house persists in selling his merchandise despite the series of negative answers given by the customer. It is a direct selling approach and sometimes it can be effective. However there are times when it irritates the customer and creates a bias against the organization that uses this approach.

2. The "soft sell" which is a subtle and suggestive apropach. Here the utility's marketing man does not try to convince the customer directly. Instead, he analyzes the customer's needs and desires and suggests solutions that in a subtle way leads the customer to conclude that buying water from the Utility or being connected to its water supply system is in its best interest.

II. *Target Markets* – include:

A. Individuals, households, organizations and other water users situated within a reasonable or economical connecting distance from the utility's distribution mains;

B. Potential customers who are not permanently based within the Utility's service area but who periodically visit it; and

C. Potential customers who are too far away from the Utility's distribution mains but who have no cheaper source of potable water.

III. *Analysis and Planning* – Given the objective and target market, the development of the strategy would involve:

A. The identification and analysis of buying (or connecting) motives or the impulses that leads to buying (or connecting) of the target markets. This in turn will lead to market segmentation and the formulation of a different strategy or general approach for each market segment. In the water utilities field, the potential customer's buying (or connecting) motives or impulses can be generally classified into:

1. Rational or economic – Where the potential customer's buying or connecting decision is primarily influenced by price and quality or what such decision maker considers as "in the best interests of his business or organization." Potential customers influenced by these motives would generally be:

   a. Businessmen and business organizations;

   b. Government corporations and organizations or institutions run by bysiness oriented executives; and

   c. Households where the decisions are made by business oriented individuals.

2. Emotional – Where the potential customer buys or connects or refuses to do so because of feelings of friendship or hate. Sometimes a potential customer may connect to a water supply system because the person he happens to deal with is friendly or "nice to deal with" or he or she may refuse to connect because such person is arrogant or high handed or discourteous.

3. Desire for Prestige – This may be a rare motive but in some primitive villages, the desire for status can also be a motive for connecting to a water supply system. A good example of this is the case where the respected and/or affluent individuals or families (the local "Joneses") in the locality are connected to the water supply system and one or a number of them allows the poorer elements of society to get water from their taps either for a monetary consideration or for free. It may also be possible that such poorer elements are able to draw their water from a local charitable institution or from a tap installed and paid for by local government. In either case, where the cat of drawing water from a public or another person's tap is highly visible and there are not too many people doing so, it is possible that some kind of a stigma can attach to such people. When it does, this may generate a strong impulse on the part of these people to have their own connections and the challenge for the Utility's Marketing unit is to evolve an arrangement whereby a connection for such people can be affordable and possible.

   Potential customers influenced by emotions and a desire for status are generally limited to individuals and households where the decision maker may be the housewife or husband who does not have a strong business orientation. Occasionally however, a government institution or other non-business organization may be influenced more by emotions rather than rational or economic motives when the decision making executive or individual also does not have a strong business orientation.

B. Market Segmentation – is the process of dividing the market into fairly homogeneous parts where any part may conceivably be selected as a target market.[2] In the water utilities field, geographic segmentation is hardly a problem, considering that the market is defined by the areas covered by the utility's distribution network. The segmentation therefore considers only two psychographic factors, i.e. benefits sought and rate of usage (consumption) and one demographic factor – income (which also affects consumption). Based on the foregoing therefore, the market for a water utility may be broadly segmented into:

1. The Residential or household market which needs water for domestic use and which may be further subdivided into:

   a. The high income households – who would potentially be big users of water but who can easily afford to set up their own private wells and pumping units;

   b. The middle income households – to whom a private well and pumping unit would be a rather big investment which may not be justified by their rate of consumption; and

   c. The low income households – who can neither afford nor justify a private well and pumping unit considering their low consumption levels, but unfortunately cannot and distribution mains as well as reservoir capacity are therefore tailored to meet such requirements. Consequently, customers with large diameter connections become primarily responsible for the installation of larger and more expensive pipes, reservoirs and other system appurtenances since their greater drawing capacities forces the utility to install such larger and more expensive facilities. Since they are responsible for the higher costs incurred by the Utility, it becomes only fair that they assume the greater burdens.

2. Non-consumers/customers of the utility who may in effect be subsidizing the Utility's operations if the latter's revenues do not fully cover all of its costs – The information campaign beamed on this particular public is perhaps the most challenging and difficult phase of the Utility's information program. This is because non-consumers rarely realize the burdens imposed on them by non-viable utilities. Since the subsidy is usually made from government funds derived from property or general taxation imposed on customers as well as non-customers of the utility, such taxation as an intervening medium effectively conceals the burden carried by non-consumers for the benefit of the Utility's Customers. Such burdens are however very real and where the levels of taxation and subsidies are high, they become onerous. The process by which burdens are imposed by non-viable utilities on non-consumers through the Taxation process has been previously discussed in this paper. At this stage what is important is to stress that the Utility's information offerings beamed on relevant non-consumers must show through a simple but clear presentation how the burden will in effect be imposed upon them if the Utility's consumers are not required to pay a level of water rates that will cover all of the Utility's requirements. Once the offerings have created an awareness, understanding and interest on the issues and the situation, it must move into a second phase, that is, it must precipitate timely action on the part of these non-consumers, maybe by setting up a lobby, holding a demonstration, or such other actions that will exert pressure on either the authorities concerned or the utility's consumers to accept a level of Rates that will make the Utility viable. Perhaps such action on the part of non-consumers may even be sought to buttress or support a previously formulated decision by the Utility to adopt a higher level of Rates required to attain or maintain viability. It is probably in this sphere of the Utility's operations that these offerings focused on non-consumers will have the greatest value. Admittedly, this phase of the Utility's public information program will probably be the most demanding in terms of planning and implementation because they seek not only passive understanding but positive action on the part of the target public. Whether the desired actions will be precipitated through a subtle approach or by way of a direct suggestion or request will depend upon the strategy developed by the Utility's Information Section, after it has made a careful analysis and evaluation of the situation.

2. Communication and Promotions – will be discussed later.

MARKETING

In the water utilities field, this is probably one of the most neglected functions. The general feeling has invariably been that this is unnecessary since the utility invariably operates as a monopoly. This may well be true in desert areas where the utility is the only source of water. However, in localities where there are other alternative sources (like groundwater or small rivers), marketing becomes an indispensable aspect of a utility's operations. This is true even where the water available from such other sources does not comply with established standards for drinking water.

1. *Objective* –

In Water Utilities, the objective of marketing is to get as many individuals, households, organizations and other water users within the service area connected to the water supply system, subject of course to the Utility's capacity to supply each such customer with their respective requirements. For potential customers who are either not permanently based within the Utility's service area (like vessels who periodically dock or call at the latter's port) or those who are too far away from its distribution lines, the objective would be to get them to buy and use as much of the Utility's water as possible. The foregoing is true whether the Utility is expected to be viable or not. In either case, the optimum utilization of its facilities is necessary to justify the utility's reason for existence, whether this be for profit, service or both. Marketing strategy for water utilities will therefore be discussed from the perspective of water utilities in general, regardless of whether such utilities are expected to be viable or not.

tions of an equitable distribution of burdens will suffice.

b. For alleged cross-subsidies within the same class of consumers with different consumption levels – This usually comes in the form of different price levels for a series of quantity blocks, with prices per M^3 either escalating by constant amounts for each successive quantity block or escalating by geometric progression at blocks in the higher consumption levels. Again this may precipitate complaints by "right wingers" specially in higher income levels that use more water – that they are in effect subsidizing the low income users at lower consumption levels who are charged a lower rate or price per cubic meter. In this case, "capacity or ability to pay" could again be interposed as a defense although it may again not have a very persuasive effect when beamed on "right wingers." Perhaps a better defense could be based on the economics of water supply systems. Typically, a water utility first exploits or develops the cheapest sources of water available to it. If this is insufficient because of a high demand for the commodity, it then progressively proceeds to tap more expensive sources. Since the higher demand may be caused by consumers who use greater quantities of water, in effect they are the people responsible for the Utility's higher costs of operation – on an aggregate as well as on a per unit basis. Since they are responsible for such higher costs, then it is only fair that they should assume the greater burdens. Even if a Utility uses the same source of water to satisfy increasing demand, there are cases where higher levels of production result in escalating marginal costs. A good example would be the case of a Utility that operates pumping units in places where power rates are escalated progressively at higher levels of consumption. Since a greater number of pumping hours or the use of larger capacity pumps will result in higher electrical consumption, the marginal costs of production will escalate. This again could be a justification for the progressive escalation of water rates at higher consumption levels. If the water utility's escalating rate structure is finely tuned in to the escalating rate structure of the power utility, the former may even interpose as a defense the fact that it is merely matching costs with revenues.

Perhaps a further defense against critics of escalated prices for higher consumption levels is the need for water conservation which can be implemented by discouraging he wasteful use of water. In areas where water resources are relatively limited, there is a need to ensure that there will be enough water for the basic needs of everybody. This is a prime concern of a water utility and in the attainment of this objective, it can and should use the price elasticities of demand, otherwise the consumers in low pressure areas will suffer because of the excessive consumptions of other consumers in high pressure areas.

c. For alleged cross subsidies effected by different levels of service charges for different sizes or diameters of service connection. – Some Water Utilities impose a service charge in lieu of a commodity charge for the first ten cubic meters of water that the consumer uses. In effect it says that its installation of a service connection up to the customer's property line or doorstep enables such customer to avail of its service everytime that he or she so desires. For good measure, the utility also throws in for free a given quantity of water (usually 10 m^3) as part of the service, but imposes a service charge rated according to the size or diameter of the service connection that the customers requested. Some customers with large diameter connections occasionally criticize this and allege that this is another way by which the utility forces them to subsidize other customers with smaller diameter connections.

Suggested defenses for this criticism could be the following:

(c.1) Customers with larger diameter connections are able to draw greater quantities of water per unit of time than those with smaller diameter connections. A customer with a 3/4 inch connection may draw roughly 60% more water per minute from the water system than another with a 1/2" connection under the same pressure conditions. In effect therefore, the former enjoys a more efficient and perhaps higher level of service than the latter. This is because he or she is able to get the required quantities of water faster than if his or her service connection were samller. Since he has opted for the convenience offered by this higher level of service, it is only fair that he pays a higher service charge.

(c.2) A water supply system is usually designed to handle or accomodate expected demands at peak hours of high consumption seasons up to a given design year. The size of transmission

Gross income	P100,000.00
Less allowable deductions	40,000.00
Net income subject to income tax	P 60,000.00
Income Tax (P60,000.00 x 50%)	P 30,000.00
Net income after deductible expenses and income tax , . .	P 30,000.00
Less: Cost of water not allowed as a deduction (10,000 M^3 of water x P2/M^3)	P 20,000.00
Net income after all expenses and Income Tax	P 10,000.00

The fact therefore that the water bills of an industrial or commercial establishment constitutes a deductible item in the process of calculating its net income subject to income tax gives it a tax shield equivalent to the applicable tax rate and in effect, the real cost of the water it uses is only the amount paid to the Utility minus the tax shield. For POLAR ICE PLANT CO., INC. this would be:

Amount paid to the Water Utility (10,000 M^3 of Water x P2/M^3)	P20,000.00
Less: Tax shield (P20,000.00 x 50%)	10,000.00
Real Cost of Water to POLAR ICE PLANT CO., INC.	P10,000.00

$$\text{cubic meter} = \frac{P10{,}000.00}{10{,}000.00\ M^3} = P1.00/M^3$$

It can therefore be readily shown that the real cost of water to a Residential consumer who is charged P1.00/M^3 by the Utility is equivalent to the P2.00/M^3 rate charged to the commercial or industrial user. Of course it can be argued that under a progressive income tax structure, not all commercial or industrial establishments are subject to the same applicable level of tax rates and indeed not all of them adopt a corporate form so that in effect, to some of them the real cost of water may be greater or less than the cost of water to the residential consumer. This argument can however be met by explaining that it is administratively impractical, if not impossible, for a utility to design its Rate structure in a way that will insure absolute equality, for in this world, absolute equality is rarely, if ever, achieved. The most that a Utility can do is approximate the equitable distribution of burdens to different consumer classes. If it can use the average income tax rate applicable to its commercial and industrial consumers as the tax shield for differential pricing, this should be fairly defensible.

– Perhaps a third line of defense for differential pricing among the above mentioned consumer groups relates to the enjoyment of fire protection benefits. It is no secret that the presence of a lot of people as well as highly combustible substances in commercial and industrial establishments make them more susceptible fo fire. In the case of commercial establishments, they are also usually located in congested areas that aggravates such risk of fire.

This, plus the fact that their buildings, inventories, furniture and other appurtenances are more valuable than those of residential consumers, makes them a primary beneficiary of the water utility's fire protection umbrella. Whether such fire protection benefits are actual – in terms of reduced rates for fire insurance premiums – or potential thru the presence of adequate pipeline pressures and strategically located hydrants, the fact remains that the greater value of their assets plus their greater susceptibility to fire makes them benefit more from the utility's fire protection capability than do residential consumers.

Since they enjoy more of the benefits, it is only reasonable to expect them to carry more of the burdens. Again, it may be difficult or impractical to come up with the precise quantitative justification or defense for price differentials based on the benefits derived from the utility's fire protection potential but, since the greater benefits to commercial and industrial establishments do exist, rough approximainstitutions.

b. Information campaigns focused on publics who can be mobilized as a pressure group to support the Viability Concept in Utility Operations should focus on the important motivation or interests of each target public. For instance:

1. Organizations, groups or individuals with a "right wing" ideological orientation should be shown how present or future government subsidies for utilities constitutes some kind of "creeping socialism" which is against their principles. On the other hand, the offerings should also demonstrate how viable utilities encourage the ideals of free enterprises, promote an ethic based on self reliance and results in efficient allocation of resources in the economy.

   For information offerings beamed on this group, the potentially most sensitive problem to face would be the existence of alleged cross consumer subsidies in a utility's Tariff structure, if any. This is because – while the utility may be espousing a self-reliance concept for itself as a whole, it may in effect be tolerating or even espousing alleged cross subsidies between different classes of consumers or even the same class of consumers with different consumption levels or demand drawdown capabilities based on the size or diameter of their respective service connections. As a general rule, it is more prudent for a utility not to bring up this matter in its information offerings. However, this does not mean that it should not prepare a defense – in case this matter is brought up. Suggested defenses could be:

   a. For alleged cross-subsidies between different classes of consumers – This usually comes in the form of differential pricing for the following consumer groups:

   (a.1) Residential consumers; and
   (a.2) Commercial and Industrial Consumers; where the water utility charges the latter a much higher rate than the former. Dependong on the circumstances, there are two ways of meeting the expected cirticism:

   – One is by accpeting the existence of a subsidy and justifying it on the basis of the general "ability to pay" of the respective classes. Since commercial and industrial users are generally more affluent and therefore can basorb higher rates, the pricing differential may indeed be palatable. There are however two weaknesses in this type of defense. The first is that it really does not satisfy the ideals of individuals or groups with the "right wing" or "conservative" ideological orientation and the second is that some commercial or industrial enterprises which are marginal or even operating at a loss may be in greater need of a subsidy than many residential consumers. This is specially true during periods of depression.

   – Perhaps a better defense would be to show the "after tax" effect of water bills or rates. It should be mentioned that to a business establishment, all the necessary costs or expenses of operating its business are allowable deductions in the process of computing its net taxable income subject to income tax. To the extent of the income tax rate applicable to the business establishment therefore, the latter enjoys a tax shield on all payments for costs or expenses which are allowable as deductions. To illustrate:

   Assume that the applicable corporate income tax rate in the country where *Polar Ice Plant Co., Inc.* operates, is 50% of its net income.

Then if: Gross income		P100,000.00
Less allowable deductions:		
1. Cost of Raw materials (10,000 M^3 of Water x P2/M^3	P20,000.00	
2. Other operating and Misc. expenses .	P40,000.00	P60,000.00
Net income subject to income tax		40,000.00
Income tax (P40,000 x 50%)		P20,000.00
Net income after all deductible expenses and income tax		P20,000.00

Notice that POLAR ICE PLANT is able to reduce its income tax liability by P10,000.00 because it could claim its payment for water bills in the amount of P20,000.00 as a deduction from gross income. If this were not an allowable deduction (as in the case of a Residential consumer in a very high tax bracket with an Olympic size swimming pool) then the financial picture would appear as shown below:

reliant and are therefore not beholden to any person or organization for charity.

2. Setting up priorities – This will depend upon the current or most immediate need of the Utility. As a matter of practice however, it is suggested that the information program be segmeneted into:

a. A continuing portion beamed on all the relevant publics heretofore mentioned except lending institutions; and

b. Speical programs focused on probable loan sources when the utility is shopping around for debt financing for expansion of its facilities or other requirements. Perhaps special programs can also be instituted to focus on other relevant publics as the necessity arises.

D. *Formulation of the Public Information Program*

1. Design of Offerings – These must be designed in the light of budgetary and time constraints, calculated impact and other environmental factors. But more than anything else, it must appeal to the particular motives of each target public which facilitates or enhances the attainment of the objectives of the public information campaign. The design of offerings must therefore create awareness, interest and the desire for the particular action sought by the utility from the atrget public. Hopefully, it will even precipitate such desired action. In addition to the relevant examples cited in the section pertaining to Utilities that are not required to be viable, we may mention:

a. For information campaigns focused on lending institutions:

1. Single or multi-government owned – the emphasis would probably be:

a. The need for improving or expanding a utility's service in a particular area or areas or even the establishment of a utility and the provision of services. The information offerings could therefore concentrate on such things aas:

(a.1) The rate of incidence of water borne diseases and its deleterious effects on the economic, social and cultural aspects of community life.

(a.2) The calculated economic and social impact of the proposed project in terms of:

- The precipitation of the establishment of industries like an ice plant, a brewery or soft drinks bottling operation or even Resorts that cater to the tourist trade;
- The creation of employment opportunities in the course of project implementation as well as other induced employment opportunities arising from the establishment of industries and businesses; etc.

b. How the implementation of the Project will help to achieve the lending institution's objectives. This will probably have to be stated in a subtle way but it could focus on such things as:

(b.1) The friendship and goodwill that will be created by the institution's loans for the Project. In this regard, the utility's information offering should show how it intends to link the institution's name to the project – maybe by strategically located signs in the Project area, or by newspaper advertisement or by the presence and participation of the lending institution's officials at the project's ground breaking or completion ceremonies, etc;

(b.2) The magnitude of imported products and services for the project which will emanate from the country which owns the lending institution or from the latter's member countries – as well as their impact in terms of the creation of export markets for spare parts, supplementary technology, etc.

c. The financial forecasts or expectations for the project, including the generation of adequate debt service coverage, return on investment, etc. – which are normally shown in conventional financial statements/documents (Projected Income Statement, Balance Sheet, Cash Flow Forecast, etc.) but which should be emphasized or presented as highlights in information brochures or materials.

2. Privately owned lending institutions – the emphasis probably would be more on past financial performance as well as future financial expectations. However, the informational offerings should not neglect any other objectives or motivations which these types of lending institutions may also have. Probably it would be relevant to state that for these types of institutions, greater effectiveness for the information campaign could be achieved if the offerings would include a section which emphasizes the institutional capability of the borrower Utility. Perhaps this could include the Utility's past operating performance as well as a thumbnail sketch of its key officials, showing their respective family backgrounds, education and relevant experience. This may be also helpful for information campaigns focused on governmental owned lending institutions but they would be more critical for these latter types of lending

Smith or his group rather than be passed on or subsidized by Mr. Adams, Mr. Clark or some other group that do not enjoy or benefit from the service. These people or organizations typically would expouse self-reliance and independence and would abhor mendicancy and subsidies.

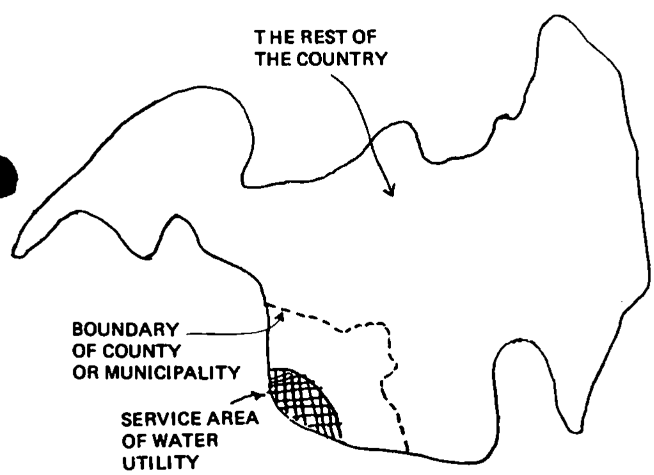
2. Non-consumers of a particular Utility – These publics are usually indifferent to events and/or activities affecting the Utility, but they do have a stake in how the Utility is financed. To illustrate – a Utility may be financed:

   a. Complete from internal cash generation – primarily thru the Water tariffs paid by Consumers/Customers (the viability concept); or

   b. Partly or wholly thru a subsidy from a philantrophist or philantrophic organization; or

   c. Partly or wholly thru a subsidy from the national government or from the local government or both.

Since the second condition is very rare and probably non-existent, it will be ignored. Instead, the assumption or carrying of the cost or burdens of the Utility in conditions (a) and (c) will be discussed. Consider a hypothetical country with a particular local subdivision (say a County or Municipality) and a Utility that serves the urban areas of such Country or Municipality. Pictorially, the whole Country could be as follows:



Under condition (a), the cost or burden of developing, maintaining and operating the Utility would be carried solely by the consumers in the service area – who benefit from the service that they pay for. Other people or households within or outside the service area who do not draw water from the Utility's mains are not encumbered or bothered with the cost of running the Utility. On the other hand, under condition (c), if a subsidy is derived from:

(b.1) The local government – then people in remote rural or other areas not served by the Utility help to pay for the latter's cost thru the Taxes that they pay. In effect, they assume burdens or costs for which no services are rendered nor benefits derived. In developing countries where the affluent reside mostly in the poblacion or urban areas while the impoverished are in the rural areas, you can have an anomalous situation where the poorer elements of society are subsidizing the water supply services of the more affluent groups. Of course this looks at taxation derived subsidies for water utilities in isolation and does not consider other benefits or services financed from taxation in general.

(b.2) The National Government – here people in other areas of the country not served by the particular Utility in question help to pay for the latter's cost thru the taxes that they pay. Of course the people in other areas served by subsidized Utilities also benefit from the taxes paid by people residing in the areas served by other subsidized Utilities. Who comes out ahead or who derives a net advantage may depend on the per capita magnitude of the taxes derived from a particular area vis-a-vis the per capita subsidy enjoyed by such area. However the discussion concerning poblacion or urban areas served by subsidized utilities as against rural areas not served by such utilities or even urban areas served by viable utilities still is valid and in effect the latter suffers a disadvantage vis-a-vis the former. Of course this is also subject to the qualification that the benefit or subsidy is viewed solely from the standpoint of utility services. Considered from the viewpoint of total taxes and governmental services, there may indeed still be a net advantage in favor of rural areas. Whether other urban areas served by viable utilities also enjoy this net advantage may be a good question.

3. Consumers of the particular utility in question – These are basically motivated by the desire to obtain optimum value for the water tariffs that they pay but they may also want to be proud of the fact that as a community they are independent of external subsidies, i.e that they are self-

consumers and other publics that viable Utility operations are an efficient and equitable way of allocating resources in the economy; and

3. To get the active and aggressive support of its different publics.

B. *The target publics* for the information program could then be similar to that enumerated for subsidized Utilities except that it would not include public as well as private donors. In lieu of this, it would have the following publics:

1. Lending institutions that may possibly finance its debt requirements; and

2. Its consumers as well as non-consumers and other publics who can probably be mobilized as a pressure group to actively support the viability concept in Utility operations.

C. *Analysis and Planning*

1. Identification and analysis of the motivations of target publics

a. Lending institutions – These may have a variety of motives and risk vis-a-vis return on investment may not necessarily be the most important.

1. Government owned institutions may be interested in:

(a) For in-country loans;

(a.1) The provision of required Utilities in certain areas that are targeted for development – say Tourism areas; and

(a.2) To precipitate or even save certain industries – say the pipe manufacturing industry; or

(a.3) It may even be interested in merely creating jobs during periods where unemployment levels are high; or

(a.4) A combination of any of the foregoing or other motives.

(b) For international loans:

(b.1) To provide required Utilities and services in underdeveloped countries or areas; or

(b.2) To precipitate economic development or growth; or

(b.3) To enhance friendship or promote goodwill or advance foreign policy goals specially in countries of strategic importance; or

(b.4) To facilitate the export of its products or technology – thus enabling it to gain a foothold in export markets; or

(b.5) A combination of any of the foregoing and other motives.

2. Multi-government owned institutions may be interested in lending for Projects or Programs/Sectors that:

a. Advances their particular objectives as well as the objectives of their member – governments; or

b. Provides the required Utilities or promotes economic growth in the borrower countries; or

c. Facilitates the export of products or services of member countries; or

d. A combination of any of the foregoing and other motives.

3. Privately owned institutions are probably the ones which have a greater concern with risk vis-a-vis return on investment. This is specially so in cases where the loans are made to investor owned Utilities and such loans are not guaranteed by the Government of the country where the Utilities are operating. However, i n cases where the privately owned institutions have a philantrophic color, they may have other motives as well. They may be interested in providing low interest laons to particular communities that their benefactor may want to favor or they may be obsessed with a desire to help depressed areas or impoverished people in particular.

In addition to the foregoing motives, it is of course obvious that all lending institutions would necessarily want that the borrower Utilities be able to meet the debt service requirements stipulated in Loan covenants. It is therefore important to highlight a Utility's historical debt service performance where this is favorable or conversely, what it intends to do to improve its debt service performance in the future. In both cases, it would probably be necessary to support an infromation campaign with a Cash Flow Forecast that indicates full debt service coverage plus a cushion to absorb unforseen events or circumstances. This meets not only the apprehensions that the lending institution may have about the Utility's debt service performance but also shows that the Utility's management is on top of its problems. It also indicates the attractiveness of the Project and satisfies an inherent desire of all lending institutions and loan officers to build up a favorable image through association with successful Projects.

b. Publics who can probably be mobilized as a pressure group to actively support the viability concept in Utility operations. These would include:

1. Organizations, officials, individuals or groups who have some kind of "right wing" ideological orientation and who therefore believe that services that benefit "Mr. Smith" or his group must be paid for by

winning its publics but also in forestalling the occurrence of personal enmities that inevitably create enemies for the Utility.

In the public relations game – where image is sometimes more important than reality – experience has shown that the public's impression of professional competence, humility, fairness and efficiency on the part of a Utility's employees significantly helps to win public support for the Utility and its programs. Perhaps this merely confirms the concept that – when people like you and trust you, they will believe you and support you. Unfortunately, the development of such an impression is a long and painstaking process and a careless remark, a haughty attitude or any wrong move on the part of a Utility's employees can often undo what has been built up for months or even years. It may therefore be a good idea to indoctrinate a Utility's employees on a number of things. Among these are:

- Avoid gruff and careless remarks or jokes. Sometimes there is a very thin line between a joke and an insult.
- Remain cool when explaining things to a Customer. Keep smiling and always remember to be courteous.
- Keep papers, books, records, furniture and other office appurtenances in a neat and orderly arrangement. This helps in projecting an image of efficiency and orderliness for the Utility and avoids a public impression of disorderly and chaotic operations which may be brought about by ramshackle arrangements in a Utility's office.
- Be firm but polite and courteous when acting on Customer complaints. Firmness implies consistency in policy implementation and negates any possible suspicion of favoritism. It also indicates that the Utility employee concerned is fully conversant with the subject that he is discussing – whatever it may be – financial, technical or operational, thus giving an impression of professional competence.
- Keep Utility offices clean and rehabilitate and repaint dirty and dilapidated-vehicles and facilities. Unsightly conditions give a bad image because people think that if these are dirty, the water supplied cannot be very different and if these are dilapidated, the Water Utility as an organization cannot be very different either.
- Try not to project the image of an elite organization. This is specially true where the Utility's salary levels are higher than those of other organizations in the locality. We know that this is good motivation and is a source of pride for the Utility's employees, but if they flaunt this is in the community, they are bound to be resented.

3. Present as well as potential customers/consumers of the Utility – to them the thrust of the program is to show that they are getting or will get good value for the price they are paying or will pay. In other words – that the exchange mechanism works in their favor, insofar as Water Supply is concerned. The information campaign should therefore emphasize the benefits that accrue – convenience and health benefits, increase in land values, fire protection, economic benefits, etc.

b. Special information campaigns focused on people or organizations (or decision makers in such organizations) which are possible sources of grants or subsidies for the Utility's projects, or who may otherwise be in a position to influence such sources – In addition to the budget officials, legislative committees and other officials previously discussed, this would include:

1. Philantrophists and philantrophic organizations where the information program should show in a subtle way how the motives behind their altruism will be satisfied by a substantial grant in favor of the Utility; and
2. Present and potential customers of the Utility where the program thrust and objectives would be to mobilize them as a pressure group to exert pressure on funding sources.

II. UTILITIES THAT ARE REQUIRED TO BE VIABLE – This would cover Utilities which must generate sufficient revenues to cover all operating and maintenance costs, debt service and an adequate surplus to provide an equity portion for future expansion of facilities and in the case of investor owned Utilities, a fair return on the investor's capital.

A. *Objectives* – the public information strategy for these types of Utilities could have objectives similar to that enumerated for utilities which are not required to be viable except that it would not seek government appropriations or private donations to subsidize its operations or capital improvements. In lieu of this, it may have the following objectives:

1. To maintain or enhance the attractiveness of the Utility as a borrower of funds from lending institutions;
2. To convince its consumers as well as non-

atone for real or imagined sins, inclusion in the List of Donors may not be as important as a gesture of gratitude by the beneficiaries of the donor's magnanimity with their expressed wishes for his happiness and well being. If the altruism is practiced in preparation for the final meeting with our supreme Creator, all the foregoing may not be as important as a Mass or some kind of religious offering made for the benefit of the donor.

2. Where time is not an important constraint. a Utility can be more thorough and methodical in planning its information campaign. In the light of its objectives, it can identify and evaluate all of its relevant "publics," establish its priorities, formulate a program and implement it thru the appropriate media. In the example previously cited, the priorities may then be rearranged and the information program can be segmented into two phases:

a. The development of a favorable institutional image and environment conducive or favorable to effective operations. This phase of the program could be on a continuing basis and could be focused on the following publics:

1. People or organizations who are concerned with environmental protection – To them the thrust of the program would emphasize the need to preserve the catchment areas of the utility's water sources as well as the protection of such sources from present and potential pollutants. The information packages must also indicate the activities which the Utility has or will undertake towards this end as well as the limits to its power. Lastly, it must make a subtle bid to get this pressure group to aggressively support the Districts' efforts.
2. Present as well as potential critics of the Utility – Here the thrust of the program would depend upon the present and potential motivations of such critics. Since these could be so numerous and varied, it will be sufficient to say that issues raised by critics should be faced squarely and perhaps a liberal dose of self examination conducted periodically by a Utility and its employees is a healthy thing. If indeed some criticisms are valid, then a Utility, after presenting its side, should accept its shortcomings and do something to correct them. This will be better for its image than trying to present excuses for an indefensible act or omission. At least, it can enhance the Utility's image of honesty and prove to its publics that while it is not perfect, it is not perfect, it is responsive and puts in its best effort. The foregoing of course assumes that the shortcomings criticized are controllable by the utility or its employees. If they are deficiencies that cannot be helped, then the Utility has nothing to apologize for. For instance, it is possible in remote areas to have extended power disruptions that may last for weeks. If the Utility's normal stock of fuel for its standby diesel engine is used up before power is restored, then the disruption in its service is not controllable. Under these circumstances, it is sufficient that the Utility presents all the facts relevant to the situation.

Insofar as critics motivated by personal enmity or grudge against one or more employees of the Utility or those motivated by a desire to replace a particular official or employee of a Utility is concerned, this real purpose or motivation on their part is rarely ever mentioned when they criticize the Utility. Normally they cite a weakness or shortcoming of the Utility (whether real or imagined) and use this as a vehicle to satisfy their desire for vengeance or to achieve their real objectives. The short run tactical approach for this type of problem is to face or meet the issues squarely insofar as the alleged weakness or shortcoming is concerned. The Utility should present its side adequately. Whether or not to expose the real motives of the critic will depend on the answers to the following questions:

a. Whether the evidence that can be presented to support the public exposure of the critic's real motives is credible in a public forum or discussion;

b. Whether the alleged weakness or shortcoming of the Utility as presented by the critic is not valid or otherwise not controllable by the Utility; and

c. Whether, in the evaluation of the Utility, it is now impossible to win the critic over to its side.

If the answers are all in the affirmative then the public ventilation of the critic's real motives may be acceptable and may serve to put the latter in a defensive posture, otherwise, it may be a wiser move to limit the public discussion to the issues raised by the critic, lest the Utility be made to appear as confusing the issues or simply putting forth "sour grapes." Under these circumstances, it may be better for the Utility to let the whole matter die down after it has presented its side and concentrate on winning over the greater majority of its publics, so that group pressure can be exerted on the recalcitrant minority. In this regard, it may not be amiss to state a few tips that Utilities can use not only in

d. Present as well as potential critics of the Utility may have a variety of motivations. These may be emotional as in cases where there may be personal enmity between them and one or a number of Utility Officials or employees or it may be merely due to a misunderstanding or lack of information on some of the Utility's programs or activities or it may even be due to legitimate grievances that have not been adequately redressed. In some cases, a critic may even be one who wants to eliminate one or a number Utility officials because he or she would like to be appointed in their place; and

e. People or organizations concerned with environmental protection are primarily interested in maintaining the ecological balance and in the cleanliness of springs, rivers and other sources of water.

2. Communication and Promotions will be discussed in a later Chapter since these are common to both Public Information and Marketing.

D. *Formulation of the Public Information Program*

Having established the objectives and target publics of the Information program and having identified and analyzed the motivations of each Target public, priorities are then established and offerings or activities are designed in the light of such motivations, budgetary and time constraints, calculated impact and other environmental factors or circumstances obtaining in the particular situation.

1. Where time is a primary constraint as in the case of a Utility that has heretofore neglected its information activities and now wants to run a crash program to obtain a Budgetary subsidy, top priority could be focused on the very source of such subsidy. In this case, it could be the Budget Office or legislative committee concerned or both, depending on which one really makes the significant decisions on the subsidy – and to be even more precise – the particular official or officials in the office or committee who really call the shots. Having identified this, the Program's offerings should be designed to focus on the motivation (both ostensible and real) of the officials concerned. Where there is a difference between the ostensible and real motivation of an official concerned and the real motivation or purpose may not be politically palatable, a two pronged information campaign may be advisable.

Example – a legislative Committee Chairman whose hometown is an economically depressed fishing area.

Real motive – Enhance his popularity and strengthen this vote getting power in the town.

Ostensible motive – Provide a subsidy that will prevent or limit escalation of Water Rates in an economically depressed town.

Based on the foregoing motivations, the information campaign would then have the following thrusts.

a. To the Committee Chairman – Show the expected effect of different levels of subsidy on the required Water Rates and demonstrate how the Utility's public information program will identify him as the benefactor responsible for preventing expected increases in Water Rates. Needless to say, the presentation to the Committee Chairman should be clear without being vulgar.

b. To other Committee members or legislators – Show how a subsidy will benefit the low income groups in the community and enhance the growth of the fishing industry and the national economy through the availability of cheap ice that is used to preserve the fishermen's catch.

c. To the water users in the Chairman's hometown – show how the subsidy will insulate the users from the costs of improving the town's water system as well as the benefits that will accrue from such improved system – better health, fire protection, etc. At this stage, it may be advisable to let the people know the significant role that the Committee Chairman plays in determining the grant and magnitude of the subsidy and – the subtle pitch would be – since we will all benefit from a subsidy, why don't you help us to convince (or exert subtle pressure) on the Chairman to grant or increase the magnitude of the subsidy.

Once the subsidy is granted, the Utility should of course make good on its word to link the Chairman to the benefits that accrued to the Community because of the windfall brought about by the subsidy.

Where the targeted source of the subsidy is a philantrophist or a philantrophic organization, the Utility must similarly identify the potential donor, appraise their motivations, develop rewarding relationships and keep them informed. To develop a rewarding relationship, the Utility's offerings and actions must be attuned to the motivations, desires and needs of the individual philantrophist or the decision maker in the philantrophic organization. For instance, if the altruism is practiced for public esteem, the donor's name must never be omitted from the List of Donors published by the Utility. If he is a really big donor, maybe even the Administration Building or a Pumping Station may be named after him. On the other hand, if the altruism is practiced to appropriate approaches, tools or blend of tools (media, communication focus or emphasis, pricing distribution, etc.) to optimize the effectiveness of the strategy adopted.

PUBLIC INFORMATION

Specific public information programs can have a variety of desired results. To a large degree, the objectives sought will depend on the national or local policies governing the operation of Water Utilities, the particular franchise or enabling legislation that created a particular utility, the policies enunciated by its policy making authority and in the case of privately owned (or investor owned) utilities, by the objectives and values of its major stockholding groups. In turn, the objectives of a specific public information program will largely distate the selection of the specific target "publics" on whom the information program will be beamed (focused) and such identification of specific target "publics" will require examination of their particular needs and desires. Let us take specific examples.

I. UTILITIES THAT ARE NOT REQUIRED TO BE VIABLE – This could cover utilities which enjoy different levels of subsidy.

A. *Objectives* – the public information strategy for these types of Utilities could include several objectives, among which are:

1. The maintenance or increase of government appropriations or private donations to support present as well as projected levels of operations/ services as well as a build up in physical facilities;

2. The maintenance or improvement/development of an image of institutional efficiency, responsiveness and professional competence – to show that the organization not only is capable but is actually serving its clientele efficiently and is responsive to the demands of the public interest; and

3. To convince the Utility's Customers that its Water Charges, if any, are equitable and necessary and that, in fact, such customers are getting or will get good or excellent value for their money.

B. *Target "Publics"* for the information program could then include:

1. The particular government agencies/offices/ officials and/or the private donors who provide or will provide the subsidy or who make the decisions on the magnitude of such subsidy.

examples – the Budget Ministry or Office, the particular legislative body – specially the legislative committees involved or in many cases the particular committee chairman or influential legislator involved or the particular Philantrophist or Philantrophic Organization that could be tapped as a source of a grant or subsidy.

2. The present customers/consumers of the Utility as well as potential customers who may be served in case the grant or subsidy sought is for an expansion/extension of service facilities.

3. Present as well as potential critics of the Utility and its programs or activities.

4. People or organizations who are concerned with environmental protection.

C. *Analysis and Planning* – Given the objectives and Target "publics," the development of the strategy would involve:

1. The identification and analysis of the "needs" or motivations of each Target public. Examples of these could be:

a. Budget Office/Official – the primary motivation or desire here could be efficient allocation of resources for the promotion of the public welfare. This could have either an economic or social objective or both.

(1) The economic objective could possibly be to bring down the cost of water to precipitate the establishment of necessary industries. Thus a water supply subsidy may be required in a fishing town where there is a need to encourage the establishment of an ice plant to provide the freezing agent that preserves the quality of the fishermen's catch.

(2) The social objective could be to bring down the cost of water in an economically depressed community;

But as a practical matter, the motivation may be more mundane. The Budget Official or the legislative committee chairman or influential legislator concerned may merely be interested in the subsidy for the water utility because he may be a resident or have vital interests or investments in the community served by the Utility or perhaps the legislator concerned may see the votes of the community involved as vital for his political career or perhaps he may even subscribe to a "left or center" ideology which favors subsidies for necessary services to low income groups in poor communities;

b. In the case of Philantrophists or philantrophic organizations, the motivation besides being altruistic could be the desire for public esteem or perhaps a desire to atone for real or imagined sins or perhaps even a preparation for the final meeting with our supreme creator;

c. Present as well as potential customers of the utility are basically motivated by the desire for optimal service at the least cost but they may partly be motivated by a desire for economic development of their community or even a sense of pride in its having adequate or modern Water Supply facilities;

MARKETING AND INFORMATION STRATEGIES FOR WATER UTILITIES

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INTRODUCTION

Every organization is a purposeful coalescence of people, materials and facilities seeking to accomplish some purpose or purposes. To survive and succeed the organization must:

1. attract sufficient resources;
2. convert these resources into products, services and/or ideas; and
3. distribute these outputs to various consuming publics.

These three tasks are normally carried on in a framework of voluntarism by the cooperating parties. The organization neither resorts to force or selfless giving. It relies mainly on offering and exchanging values to the different parties (or publics), of sufficient incentive to elicit their cooperation. In short it relies on exchange mechanisms rather than threat or love systems.[1] While Marketing calls for the offering of value to someone in exchange for value and EXCHANGE is the central concept underlying it, in this paper, Marketing will not be used as an all embracing term that covers a firm's activities or dealings with people and institutions to enhance its survival and success.

To provide distinctions and enhance clarity:

1. Informational activities addressed to or focused on people and/or institutions whose resources and/or support it wants to attract will be referred to as Public Information, or more precisely, informational activities for relevant "Publics;"

2. Activities or dealings with internal "Publics" or people whose services are needed to convert resources into products, services and/or ideas will be called Personnel Management, which includes recruitment, selection, placement, motivation, etc. of the organization's employees and/or officials; and

3. Activities or dealings to enhance the distribution of an organization's output to existing as well as potential customers/consumers will be called Marketing.

Some suggested strategies for Water Utilities involving the first and third type of activities will be discussed in this Paper while those involving the second type of activity (Personnel Management) is beyond its scope and could be the subject of another paper in a future conference. Due to the limited time available for preparation and presentation, this paper is not intended to be an exhaustive dissertation on the subject. Neither has it adhered to the fine distinctions between "strategy" and "tactics". It is only intended to highlight some of the possible directions that a water utility's public information and marketing program can take to achieve certain objectives.

In Water Utilities the development of effective Public Information and Marketing strategies requires:

1. The establishment of basic objectives to be achieved by the Strategy;

2. Selection of specific target markets or "publics" rather than a quixotic attempt to win every market or public and be all things to all men;

3. Analysis, planning, implementation and control;

4. Carefully formulated and coordinated programs rather than random actions or activities;

5. The design of the Utilities' offerings in terms of the target publics' or market's needs and desires rather than in terms of the personal tastes or bias of the utility's top Management; and

6. The selection and timely utilization of the

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[1] Boulding, Kenneth – A primer on Social Dynamics (New York: Free Press 1970)

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RESULTS OF OPERATION

Considering the entire comprehensive program for the reduction of unaccounted-for water, 7,513 leaks were repaired throughout the system for the first quarter of 1980. In addition, 3,134 sets of gate valves were investigated, 118 of which were found defective and consequently repaired. Twenty large water meters were tested in the field and two new gauging points (to be used in monitoring unaccounted-for water) were constructed with three more nearly completed. Some 108 locations of public faucets scheduled for metering were listed and initial steps were taken towards the eventual computerization of the maintenance formations of the Water Distribution and Maintenance Department. A coding system for setting and evaluation of about 30,000 job reports of leak repairs have been repaired. With respect to the unaccounted-for water the figure at the end of the quarter was 46.4% or about 2% behind the target. As for the impact on the unaccounted-for water of the system, it may be observed that the slippage of 2% could have been influenced by other factors which are now gradually being recognized after continued research on its behaviour and development with time.

Among the new factors under consideration are:

1. Relationships between unaccounted-for water and water production. Since water supply/production is varied in accordance with the available raw water supply throughout the year, targets for unaccounted-for water must be associated with the water production being considered for the period if quarterly assessments are to be made. This was not considered in the preparation of the program since the data used then were annual (aggregate) figures.
2. Effect of continued growth and expansion of water service inspite of a fixed or limited water supply capability.
3. Effect of local or general water service pressure increases/decreases on unaccounted-for water.
4. Relationships between water production and water consumption.

Studies are now in progress to determine the real impact of the program of unaccounted-for water, the results of which will be incorporated in future reports.

PROBLEMS ENCOUNTERED

The comprehensive program for the reduction of unaccounted-for water, as revised, is still behind schedule by about 2.59% of the annual target or output for the first quarter of 1980. The primary cause for this delay is manpower deficiency. Another reason is the dealy in the procurement of equipment and instruments which has previously assumed at three months delay on the average but is now taking a longer time, especially for imported items. As mentioned in the preceding topic there is increasing evidence of other factors that influence the magnitude of unaccounted-for water. Accordingly, it is still difficult to determine up to this time whether or not the delay in program implementation was the cause for the slippage in the traget for unaccounted-for water for the quarter in question. Further studies will help determine the real impact of the program on unaccounted-for water.

PROGRAM CHANGES/CORRECTIVE MEASURES

Due to some unforseen circumstances which were not considered during the preparation of the comprehensive program for reducing unaccounted-for water, the following changes were made:

1. As a result of the government's move to save as much as 25% of the current budget the following activities were negatively affected. Resource allocations and targets were reduced particularly in the accelerated leak control program where the total number of leaks to be repaired was reduced from 36,000 to 28,800. Other programs/activities affected by LOI 981 were the elimination of spaghetti connections, and transfer of water service connections to the nearest mains.
2. Due to some conflict of interest with other government agencies concerned, as well as some internal resistance within the MWSS, the program of restoring excavated streets was not considered fully for implementation. Modified portion of the program now requires MWSS contractors for major projects to restore the streets themselves. This is a compromise arrived at for projects under the Manila Water Supply Project II. This means that excavations arising from leak repairs and water service connections are still repaired and restored by the Ministry of Public Works and Highways. Allocations for this activity was also reduced due to the imposition of the 25% corporate savings under LOI 981.

In order to meet the target accomplishments for the next quarter, greater attention was being given to the immediate recruitment of additional personnel and the early acquisition of tools, materials and equipment. The proposal to increase the minimum wage of casual laborers from P15 to P18 per day was approved in order to minimize the turn over of the new casual employees and to attract more emergency laborers.

5. shift period; and
6. actual observed performance.

Teams found to be working within or above the standard performance level are recommended for incentives. The Program Coordinator submits a report of accomplishments at the end of each month to the Department Manager.

Improved Supervision

For the comprehensive program for the control of unaccounted-for water, a large portion of the total manpower is filled in by casual laborers who in many cases are new to the job. As such these people usually lack the skill and competence needed for maximum efficiency in operation. Playing the role of trainors, supervisors and regular co-workers is a smaller core group of regular employees and older casual laborers which is initially interpersed among the working crews. In cases where job accomplishments lag too fra behind the required output, the most immediate steps towards improving production is by shifting additional trained personnel from other units. This move does not require any changes in appropriations, can be done rapidly and results in improvements. In the accelerated leak control program the activities involved are so basic that there are available manpower resources assigned to other units which can be readily shifted without the need for reorientation and special training.

Incentive Program

In most production activities, the introduction of incentives, usually results in higher outputs, although not necessarily proportional in magnitude to the added costs. If for a small increase in cost due to the implementation of an incentive program a larger percentage in output is realized, then the program may be considered highly viable. This is the situation mostly prevailing in labor-intensive activities wherein the output is well below standard production levels due to manpower deficiencies. The present state of the accelerated leakage control program may be considered as approximating this situation, thus a properly designed incentive program appears desirable.

A properly designed, operated and maintained incentive program can result in improved production by:

1. Reducing the rate of resignations among emergency (casual) employees, thus minimizing the drain of expertise from the program and reducing downtime and complications involved when recruiting for replacements.
2. Boosting morale and productivity of workers due to the lure of added income.
3. Improved control of program operation and better monitoring of results.
4. Introducing a controllable flexibility in the maximum production capacity of the program, thus allowing for more accurate setting up of objectives and more efficient program implementation.

The program appraisal system discussed earlier can readily be applied to the incentive program. This method puts a weight on a piece of work done by a team or a gang, depending on the work volume and the difficulty of the work situation. Using the scoring system just described, the performance of each team can be represented objectively. In the application of the incentive program, a standard performance level can be set up above which will qualify any team/gang for some bonus wage and to adjust the performance level as required. The advantage of this program includes flexibility, responsiveness, low potential for personal conflict and easy relation to the objectives of the program.

Annex 2 illustrates an example where this incentive program is applied.

Status of Implementation

For the first quarter of 1980, some 356 leaks were located along 239 kms. of mains, resulting in a leak density of 1.4895 leaks/km. Also about 7,513 leaks were repaired throughout the system by the existing work force of 41 gangs. Program accomplishment amounted to about 26% of actual target as contrasted to the 25% expectation. For the same quarter, program performance stood at 104% of targeted output with only 85% (41 gangs) of the expected work force of 48 gans being utilized. Project cost of this program for the first quarter of 1980 amounted to P363,256.11 which excluded other costs charged to the current budget of the Water Distribution and Maintenance Department.

ANNEX 2

EXAMPLE OF APPLICATION OF INCENTIVE PROGRAM

When a team scores higher than the SPL for the month, the excess points will be converted into an equivalent amount graduation at an increasing rate. For example:

Team 5 Total No. of Points for September = 3,000
Standard Performance Level, Sept = 2.500
Excess Points = 500
Equivalent Bonus Per Point = 1.00
Collectible Incentive
Bonus, Team

Breakdown:	%	Amount
1. Team Leader	20%	P100.00
2. Skilled members	30%	150.00 at
3. Non-skilled members	50%	250.00 at P62.50

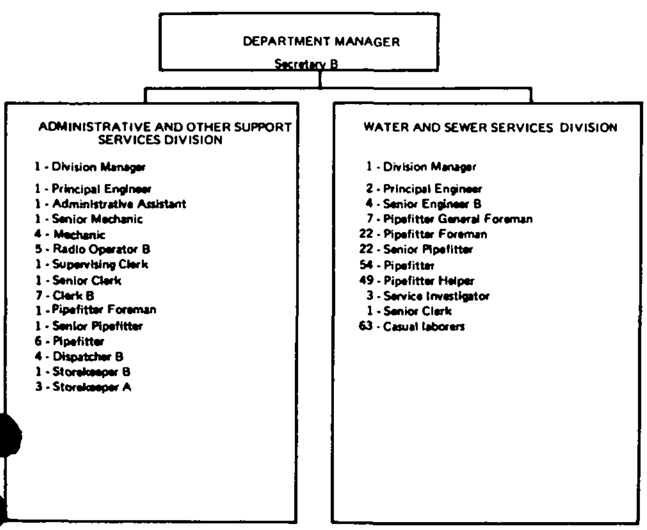
Program of Work

The program of accelerated leak control or repair is designed to be a continuing activity and therefore has no point of beginning nor end. The salient features of the leak control program includes: (1) the reorganization of and recruitment for the Operations Service Centers (OSC); (2) provisions for in-service training of new recruits; and (3) a schedule of acquisition of major equipment.

The total annual program costs for accelerated leak repair in 1980 was P15,961,163. Figure 1 shows the proposed organizational structure of the OSC of which a large component is directly assigned to the leak repair program. It will be noted that due to previous commitments for decentralization, the number of leak repair teams are divided between the Balara OSC and the Arroceros OSC. The former services the cities (except Manila) and towns found north of the Pasig River, while the latter the northern districts of Manila and all the cities and towns located south of the Pasig River. The Service Centers remain under the Operations Area.

FIGURE I

ORGANIZATION CHART
OF OPERATIONS SERVICE CENTER



Performance Appraisal

A standard performance appraisal have been established for the field teams from which the actual performance of these teams are evaluated based on a standardized performance appraisal system. The performance appraisal criteria for this particular program of leak repair (see Annex 1) can be objectively gauged using the following parameters:

1. work volume;
2. difficulty of the work situation;
3. available manpower;
4. weather;

ANNEX 1

PERFORMANCE APPRAISAL CRITERIA

1. WORK VOLUME

(A) PIPE FITTING WORK

$$P_P = (C_P S + L/3) D$$

TYPE OF PIPE	C_P
GALVANIZED IRON	2.0
PVC, PB	1.0
CAST IRON, ACP	1.5
CLAMPS	0.5
SLEEVES, ETC.	0.9

WHERE: P_P = RATING FOR PIPE FITTING WORK
C_P = PIPE-TYPE COEFFICIENT
S = NO. OF JOINTS CHANGED/REPAIRED
IF REPAIRS ARE MADE WITHOUT CHANGING PARTS,
S = 1/4 OF NO. OF JOINTS REPAIRED
L = TOTAL PIPE LENGTH, METERS
D = PIPE DIAMETER, INCHES

(B) EXCAVATION WORK

$$P_E = LW (0.3 C_E + D^2)$$

TYPE OF PAVEMENT	C_E
CONCRETE, "NATIONAL"	10
CONCRETE "PROVINCIAL"	8
CONCRETE, "MUNICIPAL"	6
ASPHALT	4
NATURAL GROUND, ETC.	2

WHERE: P_E = RATINGS FOR EXCAVATION WORK
C_E = PAVEMENT TYPE COEFFICIENT
L = EXCAVATION LENGTH, METERS
W = EXCAVATION WIDTH, METERS
D = EXCAVATION DEPTH, METERS

(C) BACKFILLING WORK

$$P_B = L W D$$

WHERE: P_B = RATINGS FOR BACKFILLING WORK
OTHER PARAMETERS AS SHOWN ABOVE

(D) HAULING WORK

$$P_H = WX$$

THIS DOES NOT INCLUDE HARDWARE MATERIALS, TOOLS AND EQUIPMENT NORMALLY BROUGHT BY THE TEAMS.

WHERE: P_H = RATINGS FOR HAULING WORK
W = GROSS WEIGHT OF MATERIAL, TONS
X = DISTANCE MOVED, KILOMETERS

2. DIFFICULTY OF WORK SITUATION

$$P_D = C_D (P_P + P_E + P_D)$$

(A) SEEPAGE ON EXCAVATION C_D = 0.10
(B) JOB UNDER WATER C_D = 0.15
(C) SHEET PILING REQUIRED C_D = 1.0
(D) LOW SECURITY AREA C_D = 0.25

THESE AREAS SHALL BE DETERMINED BY THE TECHNICAL SUPERVISORS.

3. ADVERSE WEATHER CONDITIONS

$$P_W = C_W (P_P + P_E + P_B = P_H)$$

(A) MILD STEADY RAINFALL C_W = 0.05
(B) HEAVY RAINFALL C_W = 0.10
(C) STORM SIGNAL NO. 1 C_W = 0.15
(D) STORM SIGNAL NO. 2 C_W = 0.20
(E) STORM SIGNAL NO. 3 C_W = 0.25

4. SHIFT PERIOD

$$P_S = C_S (P_B + P_H)$$

(A) MORNING SHIFT (0600 - 1400 HRS) C_S = 0.05
(B) AFTERNOON SHIFT (1400-2200 HRS) C_S = 0.03
(C) NIGHT SHIFT (2200 - 0600 HRS) C_S = 0.00

5. OBSERVED PERFORMANCE BY SUPERVISORS

(A) HIGHLY EFFICIENT, DILIGENT, INDUSTRIOUS AND ENTHUSIASTIC P_O = 5
(B) INEFFICIENT, LAXY, IMPROPER CONDUCT P_O = -5

6. EVALUATION

THE FINAL EVALUATION SHALL BE A SUM OF ALL POINTS/RATINGS CONSIDERED IN ITEMS 1 THOUGH 5 ABOVE, THUS -

$$P_T = P_P + P_E + P_B + P_H + P_D + P_W + P_S + P_O$$

THIS WILL REPRESENT THE TOTAL TEAM ACCOMPLISHMENT. TO ASSESS THE ACTUAL AVERAGE ACCOMPLISHMENT OF EACH INDIVIDUAL IN THE TEAM, THE FOLLOWING VALUES FOR RELATIVE EFFECTIVENESS OF PERSONNEL SHALL BE USED:

DESIGNATION	POINT EQUIVALENT (M)
1. FOREMAN	2.00
2. SENIOR PIPEFITTER	1.75
3. PIPEFITTER	1.50
4. LABORER WITH EXPERIENCE (OVER 1 YEAR)	1.25
5. NEWLY RECRUITED LABORERS	1.0

THE AVERAGE PERFORMANCE RATING OF THE TEAM BECOMES:

$$APR = P/\Sigma M$$

ΣM REPRESENTS THE SUM OF ALL THE TEAM MANPOWER AS MODIFIED BY THE GIVEN POINT EQUIVALENTS.

The relative difficulty in controlling water losses necessities a higher proportion of resources (85.9%) as shown in Table 1 of the total program resources with respect to the reduction in unaccounted-for water (of only 0.1%). This is justified however, by the real gains attainable which have the double effect of: (1) reducing unaccounted-for water, thus increasing revenue, and (2) increasing the available water supply for consumption. Moreover, the resources allocated to this purpose can be viewed as a permanent and lasting investment in the water distribution system facilities.

Indications of an increasing rate of unauthorized use (iilegal connections, unregistered public faucets, unauthorized use of fire hydrants, etc.) due to a deteriorating water supply can be arrested by proper metering and improved water supply due to the reduction of losses. This explains the 0.1% reduction in the unaccounted-for water despite small (3.1% of total program cost) allocation of resources (See Table 1). Table 2 shows percentage weight of individual activity and allocation of resources needed for implementing the program for the reduction of unaccounted-for water for 1980 and 1981.

Table 2

% WEIGHT OF INDIVIDUAL ACTIVITY PROGRAM

Activity/Program	Resources Allocation for 1980	% Weight	Resources Allocation for 1981	% Weight
1. Leak Detection	P 565,170	2.08	454,270	1.94
2. Accelerated Leak Control	15,961,163	58.73	13,134,932	56.44
3a Elimination of Spaghetti Connection	3,627,270	13.35)		
3 b Transfer of Tapping to Nearest Mains	1,538,210	5.66)	3,611,123	15.40
4. Repair, Rehabilitation of Gate Valves	1,652,460	6.08	1,321,184	5.63
5. Large Meter Testing	1,049,890	3.86	750,400	3.20
6a Monitoring of Unaccounted-for Water	1,324,060	-	2,767,955	11.80
6b Flow Instrumentation for Pump Stations	150,000	5.42	-	-
7. Public Faucet and Fire Hydrant Monitoring	850,420	3.13	850,420	3.63
8. Operation Center	457,470	1.68	457,470	1.96
TOTAL	P27,176,021	100.00	P23,447,754	100.00

Decentralization

As early as 1978, the program of leak repairs has been decentralized. Where before leak repair crews were all stationed at the main office these were later distributed in four different locations, namely, the Cubao Booster Pumping Station in Quezon City, Caloocan Booster Pumping Station along 7th Avenue, D. Tuazon Booster Pumping Station in Quezon City and the Ermita Booster Pumping Station in Manila. Later the decentralized station in Ermita Pumping Station was transferred to the Pasay Booster Pumping Station.

As a result of this partial decentralization, the travel time of leak repair crews was substantially reduced. In June, 1981, decentralization was also extended to such activities as installation of new water service connections and replacement of small meters. This was attained by establishing two Operations Service Centers in strategic areas within the MWSS service area.

ACCELERATED LEAK CONTROL PROGRAM

Background

An integral part of the maintenance activity of any waterworks organization involves the continuous repair of leaks in the water distribution system. A leak occurs when a portion of a pipe or fitting breaks under the combined effect of internal water pressure and the external loads such as traffic and differential settlement, thereby releasing and wasting precious water. As eralier mentioned, the MWSS has at present an estimated production-consumption ratio of 54%, which means that 46% of all the water produced is unbilled (unaccounted-for). From this unbilled water, it is estimated that about 25% is lost through leaks while the remaining 21% is attributed to other factors.

Previous studies have demonstrated that about 80% of all leakage incidents arise from broken or defective water service connections. Since a large number of repairs made on these connections recur after some time, it becomes imperative to control leaks in water service connections in order to substantially reduce wastage through leakage. At the beginning, the strategy of the program was to concentrate at high work density areas for best results. Later on, this was shifted towards reducing the reaction time from the start of the leak to its final control as the leakage density even out with continued and persistent effort at repairs. Additional resources were added to the overall effort and more effective safety measures instituted.

Of the present total of over 300,000 water services, an average of 9,600 services per year has been added since 1950. Assuming a useful life of 10 years for the locally-manufactured galvanized iron pipe used in these service connections, a potential leakage incidence of 9,600 in 1960, 19,100 in 1970 and 28,000 in 1980 can be assumed if the actual repair and replacement were adequately performed through these years. However, having observed that repairs and replacements have always lagged behind actual needs up till 1977, it can be assumed that a substantial piling up of backlogs have occurred through the years. The only way to control leakage occurrence therefore is to repair or replace at a rate greater than that projected for 1980. The present goal to repair 3,000 leaks per month is expected to be greater than the estimated potential leakage occurrence for this year and therefore will help reduce total leakage incidence. As leakage incidence decreases, losses due to leaks will also similarly decrease, although not in the same proportion. Considering that this component of unbilled water represents the largest potential recovery, it has been allocated about 57% of the total resources allocation for the control of unaccounted-for water.

tributed by the MWSS.

The monitoring of unaccounted-for water is done periodically by area and thru flow instrumentation in pumping stations and deepwells. The program is aimed at accurately determining the net production of the system through simultaneous flow measurement of the different trunk mains, deepwells, reservoirs and other instrumentation of the distribution network. This results in the identification of deficient areas through the unaccounted-for water percentage index so that priorities for various improvement programs can be properly determined. To effectively monitor the accounting fo the water flow into the selected areas, the collection district boundaries are made to conform to hydraulic considerations by temporary closure of some valves and the segregating of billing for some collection districts.

The program for the installation and metering of public faucets and the monitoring of usage of fire hydrants is designed to help in the overall efforts to reduce unaccounted-for water. It is also intended to supply water to those areas wherein very low pressures in the main do not allow proper water distribution and where concessioners have been found to resort to patronizing water peddlers. The program further seeks to estimate more accurately the total water withdrawals from the private and public use of fire hydrants.

An Action Center is being organized to coordinate various tasks and activities of the Water Distribution and Maintenance Department through a central computerized information system. More emphasis will be given to such major activities as the operation of booster pumping stations and deepwells, repair of pipe leaks, hydraulic surveys, installation of new water mains and the repair and rehabilitation of components of the water distribution system.

The in-service training program for unskilled personnel involves the systematic and controlled assignment of new personnel for the reduction of unaccounted-for water in order to maximize learning and to facilitate final placement. This activity is tired up with the formal training programs being sponsored by the Human Resources Development Office of the MWSS.

The Performance Appraisal System involves the creation calibration and operation of a system by which job accomplishments can be objectively represented in order to improve supervision and control of the numerous activities of the program for the reduction of unaccounted-for water. The program also aids in improving the accuracy in the allocation of resources.

Until recently, all the aforementioned activities comprising the comprehensive program to reduce unaccounted-for water were being executed by the Water Distribution and Maintenance Department under the Operations Area. Starting in June 1981, however, the following activities have been decentralized and transferred to two Operations Service Centers: leak repair, elimination of spaghetti connections, systematic transfer of water service connections to the nearest water mains and installation of small meters.

Although they are not included as components of the program, there are other activities that are being undertaken by other departments of the MWSS that also contribute to the reduction of unaccounted-for water. One such activity is the detection and closure of illegal connections, augmented by an informer award system. Another is the campaign to stop the unauthorized use of water from the fire hydrants for purposes other than fire-fighting.

Objectives and Targets

Since 1976 the first eight various activities and programs mentioned in the previous topic have been carried out to varying degrees of execution. As a result an estimated reduction of about 4.1% in unaccounted-for water has been realized from 1976 to 1979, or from 49.6% to 46.8%.

For 1980, target redutcion of 9.3% was set with the hope of keeping the unaccounted-for water to a level of only 37.5% by the end of the year. This was partially attained by increasing the perfomrnace targets of existing programs and by implementing new ones, namely, from No. 7 to No. 11.

In a nutshell, the objectives of the comprehensive for the reduction of unaccounted-for water are the following:

1. To reduce the unaccounted-for water to only 37.5% by the end of 1981.
2. To create, train and maintain the organization and personnel necessary for keeping the unaccounted-for water at the reduced level.
3. To develop systems and procedures which can operate and maintain the water distribution network through the transitory stage until the complete integration of the new facilities now being constructed under the Manila Water Supply Project II.
4. To provide a sound basis for future efforts to reduce unaccounted-for water.

Justifications

Considering the present billed volume of $20Mm^3$ per month, a decrease in the unaccounted-for water of, say 10%, represents an additional monthly volume of $4Mm^3$ to be saved and/or billed. In terms of direct revenue, this amounts to about P29 M per year. Expressed in terms of public service, the effect is equivalent to operating 81 new deepwells at 300 gpm capacity each deepwell.

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Austria, Jose Jr.	Neltex Development Co., Inc. 10-A, 9th Avenue Cubao, Q. C.
Academia, Elezar	Baguio City Water District Baguio City
Alba, Enrique	M. W. S. S. Water Sources & Treatment Dept. Katipunan Rd., Balara Diliman, Q. C.
Arguelles, Eduardo	National Housing Authority Elliptical Road, Diliman, Q. C.
Angara, Ponciano S.	Crown Export Co. (Phil.) Inc. 315 Buendia Ext. Makati, Metro Manila
Atienza, Tomas P.	Cotabato City Water District Cotabato City
Alviar, Teodoro	Calamba Water District Calamba, Laguna
Araullo, Alfonso Jr.	Guagua Water District Guagua, Pampanga
Alarkon, Alicia S.	Iriga City Water District Iriga City
Alvarez, Sulpicio G.	Batangas City Water District Batangas City
Afable, Ernesto R.	Balayan Water District Balayan, Batangas
Alegado, Cesario T.	Butuan City Water District Butuan City
Armena, Bernardo O.	Capitol Industrial Construction Group, Inc. 309 L & S Bldg. 1515 Roxas Blvd., Manila
Acabado, Leonila R.	1 Sandoval St. Puerto Princesa City, Palawan
Adaya, Narciso C.	National Housing Authority St. Louis Compound No. 7, Baesa, Q. C.
Aldip, Noli R.	Johnson Screen Division VOP (PTY.) LTD. 401-A LTC Bldg., Buendia Ext. Makati, Metro Manila
Almalbis, Antonio G.	Roxas City Water District Roxas City
Asuncion, Teofilo	M. W. S. S. Katipunan Rd., Balara Diliman, Quezon City
Avila, Nelia C.	Calauag Water District Calauag, Quezon
Azucena, Cesar D.	Dingle-Pototan Water District Dingle, Iloilo
Apa, Elias A.	Leyte Metro Manila District Tacloban City
Apilado, Anastacio C.	La Union Water District Sa Fernando, La Union
Baja, Luis M.	Screen Products PTE. Ltd. A. C. P.O. Box 328 Cubao, 3001, Q. C.
Bares, Flocerfina D.	Adrian Wilson Int'l. Asso. Inc. 4th Floor, Corinthian Plaza 121 Paseo de Roxas
Barilea, Rafael	Degremont Regional Headquarters 4th Floor, APMC Bldg. 136 Amorsolo St. Makati, Metro Manila
Bat-og, Romeo V.	49 Aguinaldo St., Project 4 Quezon City
Bautista, Alberto	5 Masambahin St., Diliman, Q. C.
Briones, Primitivo	Abuyog Water District Abuyog, Leyte
Baban, Pedro	La Trinidad Water District La Trinidad, Benguet
Balcita, Quintin Sr. (Dr.)	La Union Water District San Fernando, La Union
Balalta, Gregorio (Dr.)	Silang Water District Silang, Cavite

Balde, Tony Yulo II	Balde & Associates 18 Brill St., WBB Olongapo City
Balucan, Hermilo S.	40 Bulacan St., West Ave. Quezon City
Battad, Ernesto	M. W. S. S. Katipunan Rd., Balara Diliman, Q. C.
Bautista, Herminio C.	Baguio City Water District Baguio City
Bayawa, Joseph	DKK Water Consultants, Inc. 86 B. Vizcarra St. Malibay, Pasay
Belamide, Arthur	Silang Water District Silang, Cavite
Bello, P.	F. F. Cruz & Co., Inc. 800 E. delos Santos Quezon City
Benedicto, Ben (Fr.)	Davao City Water District Davao City
Buenaventura, Bernardo	Technosphere Consultants Group, Inc. 6th Floor, JEG Bldg. Legaspi Village, Makati
Blanco, Fernando	Zamboanga City Water District Zamboanga City
Barreiro, Wilfrido C.	Local Water Utilities Administration Katipunan Rd., Balara Diliman, Quezon City
Bell, Jim	Kampsax-Kruger 22 Homonhon St. Magallanes Village, Makati
Birkner, Lars	Boliden Philippines Esteban St., Legaspi Village Makati, Metro Manila
Borja, Roger	San Pablo City Water District San Pablo City
Borromeo, Carlos M.	Eternit Corporation F. Blumentritt Ext. Mandaluyong, Metro Manila
Borromeo, Joel B.	Tanjay Water District Tanjay, Negros Oriental
Bosa, Antonio B.	Masbate Water District Masbate, Masbate
Boyon, Rogelio	Camarines Norte Water District Camarines Norte
Bucoy, Juanita	Zamboanga City Water District Zamboanga City
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Cordoba, Casimiro	National Water Resources Council 8th Floor, NIA Bldg. EDSA, Quezon City
Cerrafon, Luis	Marcelo St., Valenzuela Metro Manila
Cerna, Pastor dela	Malaybalay Water District Malaybalay, Bukidnon
Cruz, Nilo dela	Rural Water Works Development Corp. 929 P. Noval St. Sampaloc, Manila
Cabanela, Oscar A.	Camarines Norte Water District Daet, Camarines Norte
Cabato, Jose Jr.	Pagadian City Water District Pagadian City, Zamboanga del Sur
Caligtan Herman	La Trinidad Water District La Trinidad, Benguet
Campomanes, Guillermo	Cotabato City Water District Cotabato City
Capile, Diosdado P.	The Edward J. Nell Company 4131 Bougainville, Sunvalley Subd. Paranaque, Metro Manila
Capistrano, Alfredo H.	Trans-Asia (Phil.) Inc. 83 4th St., Riverside Village Sta. Lucia, Pasig, MM
Calpotura, Clemente	Baguio City Water District Baguio City
Capulong, Avelino V.	Davao City Water District Davao City
Carlos, Rolando O.	LUPATA Water District Lucena City
Carpio, I.	F. F. Cruz & Co., Inc. 800 E. delos Santos Ave. Quezon City
Carrasco, Agustina B.	Camarines Norte Water District Daet, Camarines Norte
Casiño, Percival	Apex Mining Co., Inc. 4th Floor, Ortigas Bldg. Pasig, Metro Manila
Cating, Moises	Baguio City Water District Baguio City
Castillon, Danilo J.	B53 L12, Lagro Subdivision Novaliches, Quezon City
Certeza, Tim Jr.	Certeza Development Corp. 2nd Floor, Culmat Bldg. E. Rodriguez Sr. Avenue Quezon City
Chapman, Michael John	7 Barcelona St. Merville, Paranaque, MM
Chan, Robert	Atlanta Vinyl Corp. 97 9th Avenue, Grace Park Caloocan City
Cesa, Estanislao	Olongapo City Water District Olongapo City
Chang, Antonio	Masbate Water District Masbate, Masbate
Chavez, Juan	Camarines Norte Water District Vinzons, Camarines Norte
Chiong, Dominador	Baybay Water District Baybay, Leyte
Clauson-Kaas, Jes	Cowiconsult 19 Arthur St. San Juan, Metro Manila
Cobankiat, Ricardo L.	Cobankiat Hardware 495 Q. Paredes St. Binondo, Manila
Crisostomo, Diomedes	M. W. S. S. Katipunan Rd., Balara Diliman, Quezon City
Cruz, Almita	Bislig Water District Bislig
Cruz, P.	F. F. Cruz & Co., Inc. 800 E. delos Santos Ave. Quezon City

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Cruz, Florante dela	La Union Water District La Union
Cruz, Vergel de la	Local Water Utilities Administration Katipunan Road, Balara Diliman, Quezon City
Daodao, Amy K.	La Trinidad Water District La Trinidad, Benguet
Daodao, Magno	La Trinidad Water District La Trinidad, Benguet
Dayot, Ernesto	Dingle-Pototan Water District Dingle, Iloilo
Dayrit, Modesto Jr.	Philnor Consultants & Planners, Inc. Metro Manila
Delascoste, Jules	583 Colgate St., East Greenhills Manila
Demasu-ay, Luzel	Metro Iloilo Water District Jaro, Iloilo City
Dimaano, Benjamin	Bendimil Construction Pasonanca, Zamboanga City
Dizon, Arsenio M.	Balanga Water District Balanga, Bataan
Dimzon, Mario S.	DCCD Engineering Corporation 1407-B Gov. Forbes St. Sta. Cruz, Manila
Dolorico, Julio (Dr.)	Leyte Metro Water District Tacloban City
Domingo, Jose Jr.	Mabalacat Water District Mabalacat, Pampanga
Durante, Augustus D.	3-A Caerino St., Project 4 Quezon City
Durias, Eutiquio	Iligan City Waterworks System White Plain St., Iligan City
Dyloco, Pedro	Camarines Norte Water District Camarines Norte
Ela, Norberto L.	North Cotabato Water District Kidapawan, North Cotabato
Elizaga, Benjamin	Philippine Waterworks & Const. Corp. J. Elizalde St., B.F. Homes Paranaque, Metro Manila
Elaog, Reynaldo	Managerial Resources Corporation 357 Buendia Avenue Makati, Metro Manila
Eleazar, Jose M.	Calauag Water District Caluag, Quezon
Eleazar, Roberto	Eternit Corporation 725 F. Blumentritt Ext. Mandaluyong, Metro Manila
Enriquez, Juanita J.	Zamboanga City Water District Zamboanga City
Escobar E.C.	Cagayan de Oro City WD Cagayan de Oro City
Españo, Romeo	Zamboanga City Water District Zamboanga City
Espina, Margarito G.	Dingle-Pototan Water District Dingle, Iloilo
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Eufemio, Adolfo Col. (Ret.)	Certeza Development Corp. 2nd Floor, Culmat Bldg. E. Rodriguez Sr., Ave., Q.C.
Eusebio, Rodolfo Y.	Chemphil Manufacturing Corp. 851 Chemphil Bldg. Pasay Road, Makati MM
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Evasco, Numeriano	Bislig Water District Bislig, Surigao del Sur
Faller, Rodolfo	LUPATA Water District Lucena City
Fanto, Cirilo	Olongapo City Water District Olongapo City
Fauni, Avelino	Dasmariñas Water District Salitran, Dasmarinas, Cavite
Feliciano, Ranulfo C.	Leyte Metro Water District Tacloban City
Ferrer, Annie	Mabuhay Vinyl Corporation 356 Guevarra Avenue San Juan, Metro Manila
Fierro, Eduardo del	M. W. S. S. Katipunan Road, Balara Diliman, Quezon City
Figuerres, Crisostomo A.	Bureau of Water Supply Port Area, Manila
Figueroa, Leon M.	Construction Dev. Corp. of the Phils. 3593 M. Torres St., Bacood Sta. Mesa, Metro Manila
Flaviano, Juliana (Dr.)	Bocaue Water District Bocaue, Bulacan
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Flores, Crescencio F.	Cotabato City Water District Cotabato City
Flores, Guillermo S.	PMDSI 48 Mindanao, Filipinas Village Marikina, Metro Manila
Florido, Bernardito	Metro Cebu Water District Cebu City
Fortuno, Jaime	Metro Naga Water District City Hall, Naga City
Francisco, Renato A.	Cabanatuan City Water District Cabanatuan City
Frederiksen, Paul-Erik	M. W. S. S. Katipunan Rd., Balara Diliman, Quezon City
Garcia, Fredesvindo G.	M. W. S. S. Katipunan Rd., Balara Diliman, Quezon City
Guevarra, Bambi	Mabuhay Vinyl Corporation Metro Manila
Guevarra, Tirso D.	Lipa City Water District Bgy. Tambo, Lipa City

Greenman, David W.	c/o Electrowatt Philippines MWSS, Katipunan Road Balara, Quezon City
Gonzales, Julio C. Jr.	Go Tong Electrical Supply Co., Inc. 3833 Biyaya St., Bacood Sta. Mesa, Manila
Gloria, Manuel	Dumaguete City Water District Dumaguete City
Giron, Jose Y.	DCCD Eng'g. Corporation Sol Bldg., F. Amorsolo St. Makati, Metro Manila
Gines, Romulo F.	Trans-Asia (Phils.) Inc. 22 Jasmin St., Elvinda Village San Pedro, Laguna
Gomez, Gerardo Jr.	Tarlac Water District Tarlac, Tarlac
Gervacio, Alejandro	C. L. Almajose & Sons 2104 V. V. Soliven Bldg. EDSA, Q. C.
Gapuzte, Benito	La Union Water District La Union
Garcia, Vicente Jr.	Davao City Water District Davao City
Ganhinhin, Guido	Moldex Products, Inc. 3 West Sixth Street Quezon City
Gammad, Rosalito	Tuguegarao Water District Tuguegarao, Cagayan
German Alfredo	Bocaue Water District Bocaue, Bulacan
Guzman, Ruben de	Block 5, Lot 16, Phase III Pacita Complex, San Pedro Laguna
Guzman, Romanito de	Olongapo City Water District Olongapo City
Hebert, Paul V.	World Bank/UNDP 68 4th Street, New Manila Quezon City
Halili, Tarcisio	Mabalacat Water District Mabalacat, Pampanga
Hernandez, Ruben	M. W. S. S. Katipunan Rd., Balara Diliman, Quezon City
Helmick, Calvin C.	6 Yellowstone St. White Plains, Q. C.
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Ilustre, Oscar	M. W. S. S. Katipunan Rd., Balara Diliman, Q. C.
Ibarra, Romulo	Camiling Water District Camiling, Tarlac
Ibrado, Milo S. Jr.	Chemphil. Mfg. Corp. 851 Chemphil Bldg. Pasay Rd., Makati, MM
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Jesus, Pedro de	Tarlac Water District Tarlac, Tarlac
Jiongco, Luisito	Rural Water Works Development Corporation 976 Basilio St., Sampaloc, Manila
Jancobsen, Henning	c/o MWSS-Kampsax Kruger Katipunan Rd., Balara Diliman, Quezon City
Javier, Leonardo	Dasmarinas Water District Dasmarinas, Cavite
Jereza, Alfredo T.	La Carlota City Water District La Carlota City, Negros Occ.
Jereza, Margarita T.	La Carlota City Water District La Carlota City, Negros Occ.
Jota, Jose L. Jr.	Air-Mat Handling Equipment, Inc. P. O. Box 1170 MCC Makati, Metro Manila
Jugo, Luisito L.	DCCD Engineering Corp. Sol Office Condominium Amorsolo St., Makati, MM
Juinio, Editha B.	DCCD Engineering Corp. 90 Scout Rallos, Q. C.
Kline, Jessi	534 Lafayette St. East Greenhills, San Juan Metro Manila
King, Harvey L.	Johnson Screen Division VOP (Pty) Ltd. 401-A ITC Bldg., Buendia Ave. Ext. Makati, Metro Manila
Kwok, Linda Y.	Supersound Mktg/Baesa Foundry Metro Manila
Leano, Carlos C.	Local Water Utilities Administration Katipuna Rd., Balara Diliman, Quezon City
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Leon, Macario B. de	Olongapo City Water District Olongapo City
Lee, Edwin	World Health Organization Box 2932, Manila
Labrador, Perfecto O.	Adrian Wilson Int'l. Asso. Inc. 4th Floor, Corinthian Plaza 121 Paseo de Roxas, Makati
Lachica, Solomon	Filipino Pipe & Foundry Corp. Cembo, Ft. Bonifacio
Lara, Edward R.	C & A Const., Co., Inc. UPS V, Sucat Road Paranaque, Metro Manila
Lara, Rodolfo	Go Tong Electrical Supply Co., Inc. Metro Manila
Larsen, Bo	Kampsax-Kruger Inc. 6th Floor, Casmer Bldg. Salcedo St., Makati

Larsen, Hugo	c/o MWSS-Kampsax Kruger Katipunan Rd., Balara Diliman, Q. C.
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Lardizabal, George R.	Puerto Princesa City WD Puerto Princesa City
Lazaro, Angel III	160 Panay Avenue Quezon City
Legarda, Enrique II	Catbalogan Water District Catbalogan, Samar
Locquiao, Ricardo	F. F. Cruz & Co., Inc. EDSA, Quezon City
Lim, Antonio W.	Concept Builders, Inc. 355 Maysan Road, Valenzuela Metro Manila
Lorica, Rennener C.	San Pablo City Water District 73 Schetelig Avenue San Pablo City
Luna, Benjamin	Lipa City Water District Lipa City
Luna, Raphael	DKK Water Consultants, Inc. 6th Floor, Casmer Bldg. Salcedo St., Legazpi Village Makati, Metro Manila
Laureano, Guillermo	Cotabato City Water District P. O. Box 305, Cotabato City
Lontok, Alfonso	Los Banos Water District Los Banos, Laguna
Lopez, Federico Cesar, Jr.	DKK Water Consultants, Inc. 6th Floor, Casmer Bldg. Salcedo St., Legaspi Village Makati, Metro Manila
Lopez, Silvio M.	5th Floor, Cibeles Bldg. Ayala Ave., Makati, MM
Macabando, Sultan Monsing	Marawi City Water District Marawi City
Macaraig, Arturo	Batangas City Water District Batangas City
Magbanua, Juanito T.	Dumaguete City Water District Dumaguete City
Magdael, Manuel D.	Cotabato City Water District Cotabato City
Makasiar, Aurora M.	Zamboanga City Water District Zamboanga City
Mamitag, Luis A. Jr.	Ministry of Public Works & Highways Port Area, Manila
Manalaysay, Marcial	M.W.S.S. Katipunan Rd., Balara Diliman, Q. C.
Mapalo, Bienvenido	Baguio City Water District Baguio City
Maniago, Josefa J.	Guagua Water District Guagua, Pampanga
Macatangay, Ernesto	Mono Pumps Australia Merchants Bldg., Buendia Makati, MM
Maniquis, Gaudencio	J. V. Angeles Const. Corp. Bagong Ilog, Pasig, MM
Mantiza, Sergio Jr.	Malaybalay Water District Malaybalay, Bukidnon
Maranan, Nilo M.	Batangas City Water District Batangas City
Marasigan, Nemesio	Hydro-Tech Industries, Inc. 2561 Espiritu, Singalong, Manila
Marcelo, Homer	San Pablo City Water District San Pablo City
Mariano, Efren	DCCD Engineering Corp. 612 Dandan St., Tondo, Manila
Matawaran, Jose E.	Inchem Manila Domestic Insurance Bldg. Port Area, Manila
Mendoza, Armin S.	Hydro-Tech Industries Inc. V. Cordero St., Marulas Valenzuela, Metro Manila
Morales, Lazaro Jr.	Camarines Norte Water District Daet, Camarines Norte
Mendoza, Honesto D.	Batangas City Water District Batangas City
Mendoza, Guillermo	M. W. S. S. Katipunan Road, Balara Diliman, Q. C.
Murray, Nigel	Metropolitan Waterworks Sewerage System 22 Juan Luna, San Lorenzo Village Makati, Metro Manila
Munsayac, Gelacio	Baguio City Water District Baguio City
Morales, Antonio	Lipa City Water District Lipa City
Morales, Eulogio	Olongapo City Water District Olongapo City
Malbas, Marina	136 Quezon Blvd., Kidapawan North Cotabato
Madrid, Peter-Paul	Ekistics Philippines, Inc. Suite 106 BF Condo, Intramuros Manila
Monsanto, Romeo	Metro Cebu Water District Cebu City
Maglasang, Tomas	Metro Cebu Water District Cebu City
Moro, Crispin	Drilling Corporation of Asia 7337 J. Victor St., Makati, MM
Morceli, Urs	Motor Columbus Local Water Utilities Administration Katipunan Rd., Balara, Q. C.
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Morando, Virgilio	Pacific Erectors, Inc. 6th Floor, Liberty Bldg. Pasay Road, Makati, MM
Maxino, Luciano	Dumaguete City Water District Dumaguete City
Manzano, Hermenegildo	DCCD Engineering Corp. 612 Dandan St., Tondo, Manila
Manzano, Norma	DCCD Engineering Corp. 612 Dandan St., Tondo, Manila
Molano, Antonio Jr.	Rural Waterworks Development Corp. 976 Basilio St., Sampaloc, Manila

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Mercado, Juanito N.	Moldex Products, Inc. 3 West Sixth Street Quezon City
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Neri, Augusto F.	Cagayan de Oro Water District Cagayan de Oro City
Neri, Ruben JB	Misamis Occidental Water District Misamis Occidental
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Nunez, Jose P. (Dr.)	Misamis Occidental Water District Ozamis City
Ocampo, Lamberto Un	DCCD Engineering Corp. Sol Bldg., Amorsolo St. Makati, MM
Olgado, Ibarra J.	Local Water Utilities Administration Katipunan Rd., Balara Diliman, Q. C.
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Ong, Benito L.	Zamboanga City Water District Zamboanga City
O'Santos, Jose V.	Bocaue Water District Bocaue, Bulacan
Osmena, Rogelio	Metro Cebu Water District Cebu City
Quano, Eustaquio S.	Metro Cebu Water District Cebu City
Pugeda, Sonny Moss Jr.	Fil-Eslon Mfg., Corp. 6th Floor, AIU Bldg., Dela Rosa Makati, Metro Manila
Prieto, Marcos V.	La Union Water District La Union
Ponce, Jorge	Technosphere Consultants Group, Inc. 2129 Ilustre, Sta. Cruz, Manila
Piczon, Candido	Catbalogan Water District Catbalogan, Samar
Perez, Zoilo	San Jose Water District 2 San Jose, Occidental Mindoro
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Paredes, Fernando	Silang Water District Silang, Cavite
Paraiso, Pio Jr.	Bureau of Water Supply Port Area, Manila
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Pascual, Alfonso	Subic Water District Subic
Pasia, Leonardo	Davao City Water District Davao City
Pascua, Wilson	La Union Water District La Union
Pasaporte, Aurelio	Dingle-Pototan Water District Dingle, Iloilo
Parra, Luisito	Tagaytay City Water District Tagaytay City
Panotes, Elmer	Camarines Norte Water District Camarines Norte
Panganiban, Ramon	Hydro-Tech Industries, Inc. 7 J. Ruiz, San Juan, Rizal
Pajuelas, Pedro Jr.	Puerto Princesa Water District Puerto Princesa City
Padoginog, Macandita	Dingle-Pototan Water District Dingle-Iloilo
Quebral, Ricardo T.	M. W. S. S. Katipunan Rd., Balara Diliman, Q. C.
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Quinto, Iluminado	Davao City Water District Davao City
Roxas, Eleazar N.	Bocaue Water District Bocaue, Bulacan
Ramirez, Gregorio Jr.	Bocaue Water District Bocaue, Bulacan
Ramiro, Apolinar Z.	Engineering Deve. Corp. of the Phils. South Superhighway, Metro Manila
Rammelkamp, James	JMM Consultants, Inc. c/o LWUA, Katipunan Rd., Balara Diliman, Q. C.
Ramos, Arturo	DCCD Engineering Corp. Sol Bldg., Legaspi Village Makati, Metro Manila
Ramos, Virginia	Zamboanga City Water District Zamboanga City
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Reyes, Angel	District Engineers Office Malabon, Metro Manila
Reyes, Napoleon Al	Davao City Water District Davao City
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Roque, Rolando	DCCD Engineering Corp. Sol Bldg., Makati Metro Manila
Ronquillo, Constantino	Liloy Water District Liloy, Zamboanga del Norte
Respicio, Alfredo	North Cotabato Water District Kidapawan, North Cotabato
Saavedra, Nilo	960 E. Quintos St., Sampaloc Manila
Sabal, M. C.	Cagayan de Oro City Water Dist.

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Salvo, Eluderio	Rm. 307 Pyramid Bldg. 160 West Ave., Quezon City
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Santiago, Edralina	Malaybalay Water District Malaybalay, Bukidnon
Santos, Primitivo	National Water Resources Council 8th Flr., NIA Bldg., EDSA' Q. C.
Santos, Jose D.	c/o Atlas COPCO (Phils.) Inc.
Santos, Mariano M.	112 Mt. Fairweather St. Filinvest Homes I, Q. C.
Santos, Antonio P.	Santiago Water District Santiago, Isabela
Sarausad, Jesusa	Bureau of Water Supply Ministry of Public Works and Highways
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Sebastian, Leon P. Sr.	Rajah Soliman, San Jose Occidental Mindoro
Seludo, Jose	M W S S Katipunan Road, Balara, Q. C.
Semaña, Domingo R.	Lipa City Water District Lipa City
[illegible]y, Nelson	146 National Highway, Pamplona Las Pinas, Rizal
Sumperos, Leonardo	No. 4 Marinduque, SFDM, Q. C.
Suguitan, Albert	Local Water Utilities Administration Katipunan Road, Balara Quezon City
Soriano, Camilo	Tuguegarao Water District Tuguegarao, Cagayan
Simbulan, B. H.	Cabanatuan City Water District Cabanatuan City
Tsutomo Shigemori	Kurimoto Iron Works, Ltd. 7th Floor, China Bank Bldg. Paseo de Roxas, Makati, MM
Silva, Esteban	Filipino Pipe & Foundry Corp.
Tanjuakio, Avelino	Tarlac Water District Tarlac, Tarlac
Tadeo, Eugenio V.	Baguio Water District Baguio City
Tanos, Lourdes	Baguio City Water District Baguio City
Ticlao, Ricardo I.	111 Aguirre St., Legaspi Village Makati, M.M.

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Tortes, Gwilym M.	13 Albany, Greenhills Makati, M. M.
Trinos, Antonio T.	Madonna Lily St., Lillesville Subd. CAmarin, Caloocan City
Tolentino, Raquel A.	San Pablo City Water District San Pablo City
Tolentino, Enrique B.	No. 4 San Roque, Kapitolyo Pasig, M. M.
Toledo, Gil S.	Silang Water District Silang, Cavite
Tawatao, Ernesto	Olongapo City WD, Olongapo City
Tolentino, Eugenio D.	Bislig Water District Bislig, Surigao del Sur
Tan, Francis	Atlanta Vinyl Corp. 97 9th Aven., Grace Park Caloocan City
Tang, James	P. O. Box 1566, Manila
Trocino, Henry	Bacolod City Water District Bacolod City
Tuano, Abelardo Tizon	Misamis Occ. Water District Misamis Occidental
Uluan, Federico P., Jr.	Cotabato City Water District P.O. Box 305 Cotabato City
Valdehuesa, Manuel B.	Cagayan de Oro City Water Dist.
Valdez, Fredelito C.	Puerto Princesa City Water Dist. Puerto Princesa City
Valencia, Josefa L.	Cotabato City Water District P. O. Box 305, Cotabato City
Vega, Jaime O.	Baybay Water District Baybay, Leyte
Valenzuela, Romeo S.	Philippine Brass Co., Inc. 33 Kaingin Rd., SFDM, Q. C.
Veloso, Alfredo R.	Metropolitan Cebu Water District Cebu City
Veloso, Milagros E.	Metropolitan Cebu Water District Cebu City
Verwoert, Dirk H.	6th Flr., Casmer Bldg. Salcedo St., Makati, MM
Villaluz, Froilan L.	Camarines Norte Water Dist. Daet, Camarines Norte
Villanueva, Reynaldo R.	City Engineer's Office Davao City
Villar, Estrella T.	735 Tomas Mapua St. Sta. Cruz, Manila
Villarama, Renato C.	16 West Maya Dr., PHILAMLIFE Homes, Quezon City
Villasan, Arturo G.	Cabanatuan City Water District Cabanatuan City
Vildzius, Romualdas	1524 Carissa St., Dasmarinas Makati, Metro Manila
Villon, Mario E.	17 Guerilla St., Sto. Nino Marikina, Metro Manila
Vytiaco, Antonio V.	Bulan Water District Bulan, Sorsogon

Waterhouse, Kenneth A.	21 Zinia St., Valle Verde 2 Pasig, Metro Manila
Wiberg, Kent	Mabuhay Vinyl Corp. 6th Floor, AIU Bldg. Dela Rosa St., Legaspi Village Makati, Metro Manila
Yalong, Joel	Baguio Water District Baguio City
Yamson, Wilfred	Davao City Water District Davao City
Ybañez, Jesus R.	Metropolitan Cebu Water District Cebu City
Ycaro, Godofredo	Malaybalay Water District Malaybalay, Bukidnon
Zabala, Maria S.	Leyte Metropolitan Water District Tacloban City
Zabat, Mario D.	22 St. Joseph, Paradise Village Quezon City
Zurbito, Manuel L.	Masbate Water District Masbate, Masbate

3RD ASIA PACIFIC REGIONAL WATER SUPPLY CONFERENCE AND EXHIBITION

NOV. 15 - 19, 1981
PICC, MANILA PHILIPPINES

INTERNATIONAL WATER SUPPLY ASSOCIATION
ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

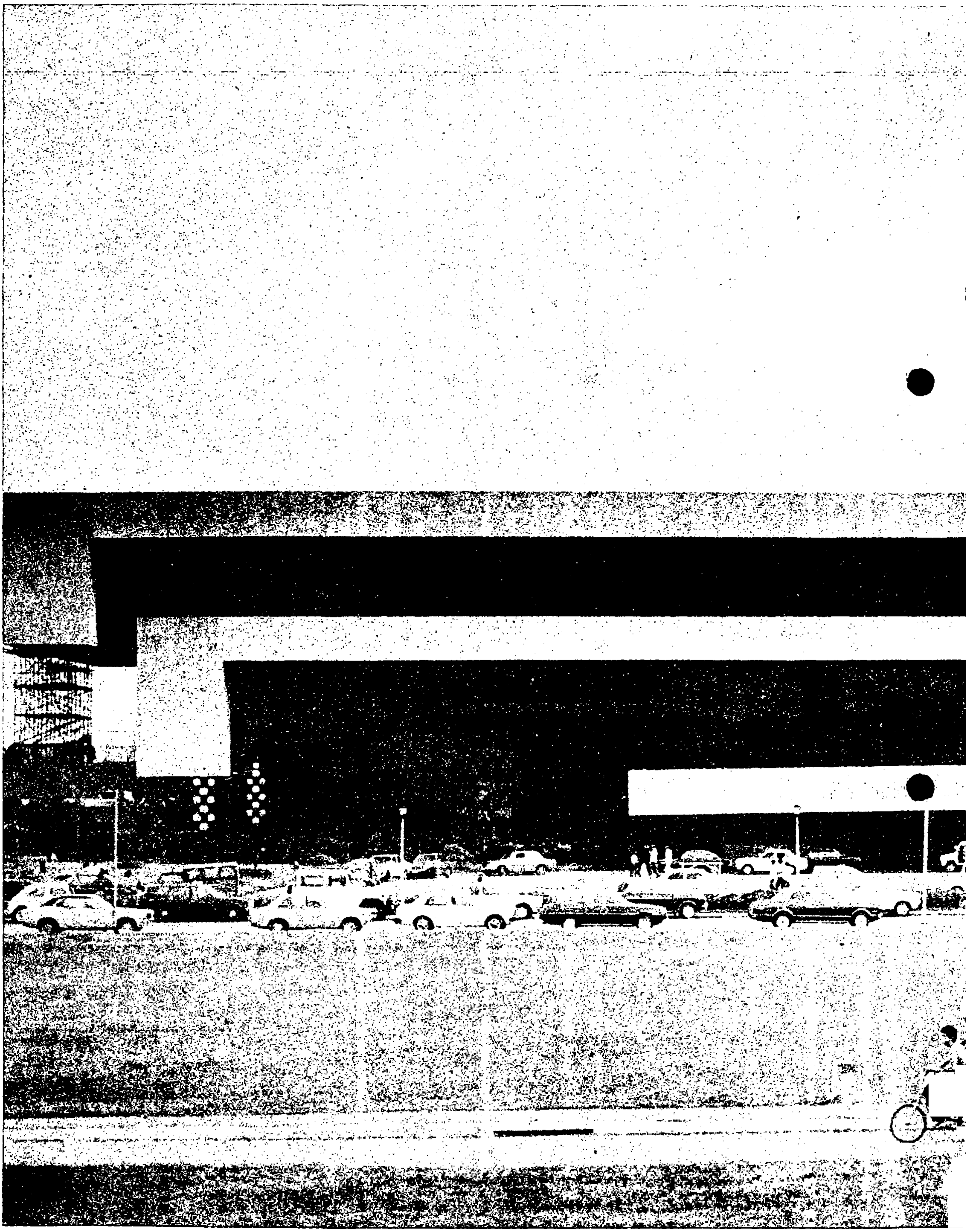
PHILIPPINE WATER WORKS ASSOCIATION

PHOTO SOUVENIR ALBUM

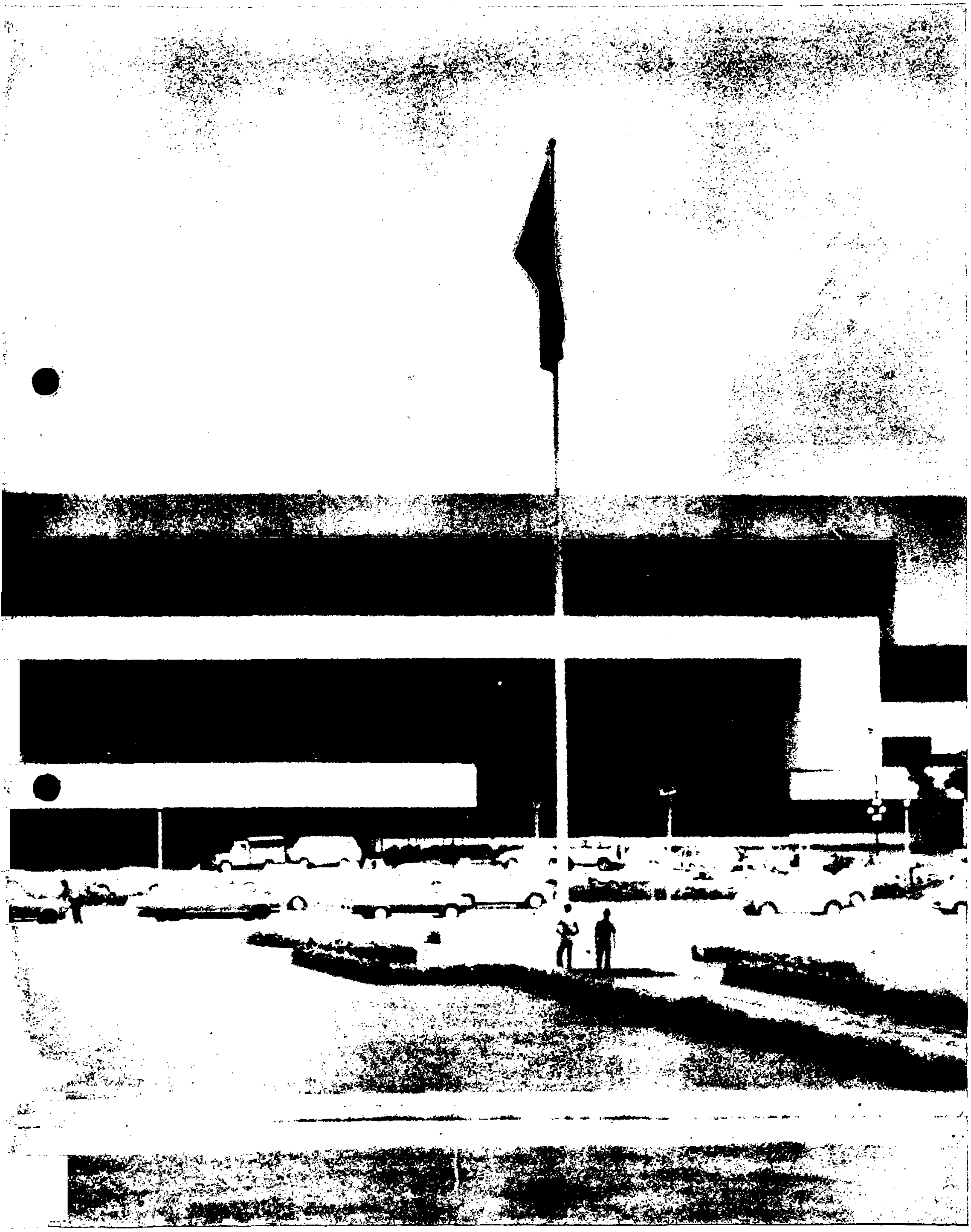
"WATER SUPPLY DEVELOPMENT IN THE ASIA-PACIFIC REGION IN THE 80s"

– Conference's Theme

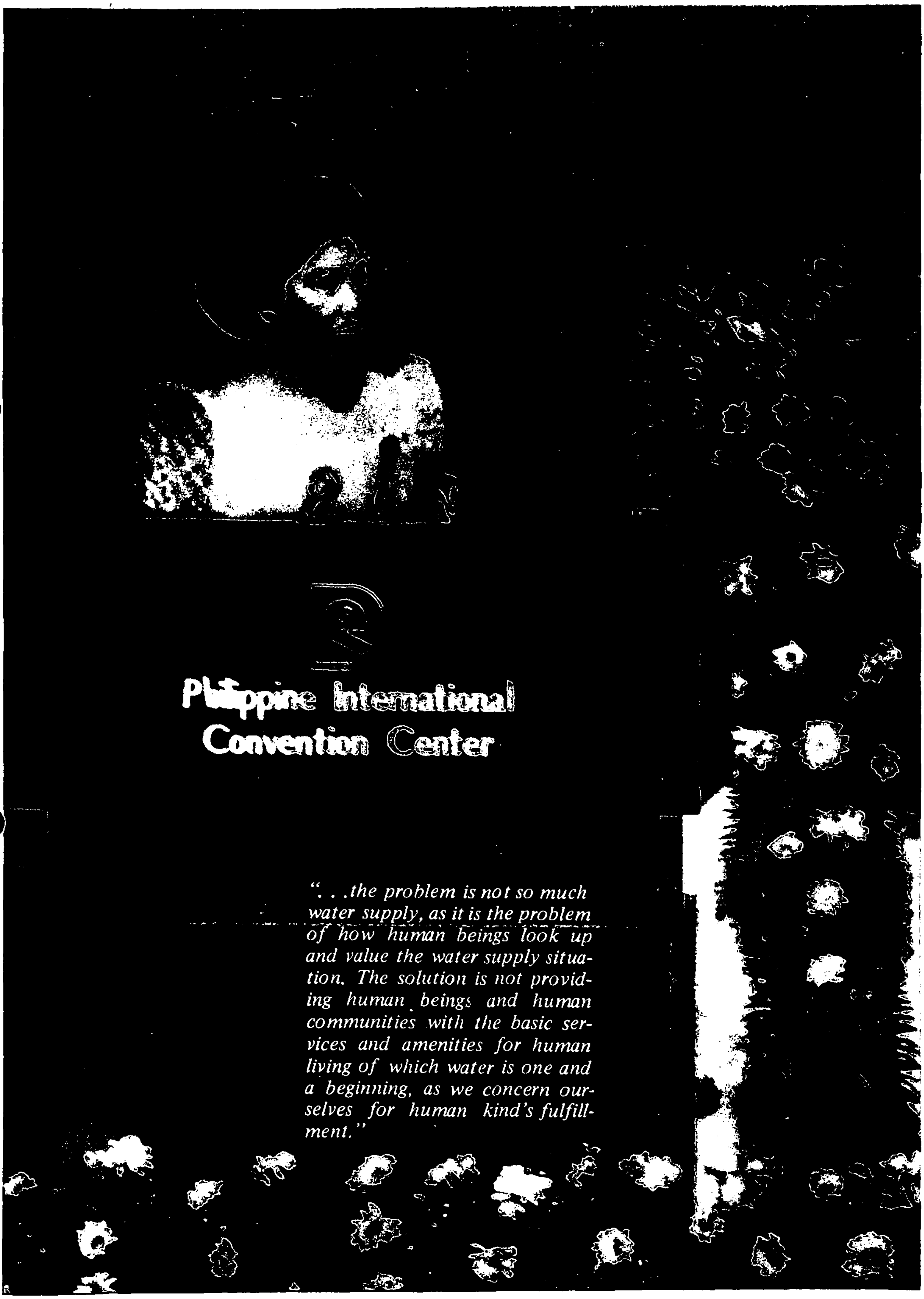
The Conference. The 3rd Asia-Pacific Regional Water Supply Conference & Exhibition, in Manila Nov. 15-19,1981, was more than just a part of a series of conferences for the development of water supply in the region. It was a whole event by itself in many aspects and for as much reasons. For one, the conference saw the first time in the history of water supply where ranking experts in the field from all over the world gathered together to share experiences and expertise. Water doyens from Europe and the Americas traveled to the far east just for the occasion. It was not only therefore, a meeting for and within the region; it was for the world, for anyway, water supply is not just a regional concern, it is a worldwide effort. If the record turn-out of participants is an indication, either the worldwide water supply condition is a lot worse than we ever deem it to be or that our friends in the industry, all over the world are one in the desire to achieve and support the conference's objectives of demonstrating awareness in new potential technologies in water supply and of pursuing the aims of the United Nation's declared International Water Decade. The presentation of around 42 technical papers and exhibition of material equipment in water supply in almost every conceivable condition, we have little doubt, made the 5-day conference a worthwhile and enriching endeavor.



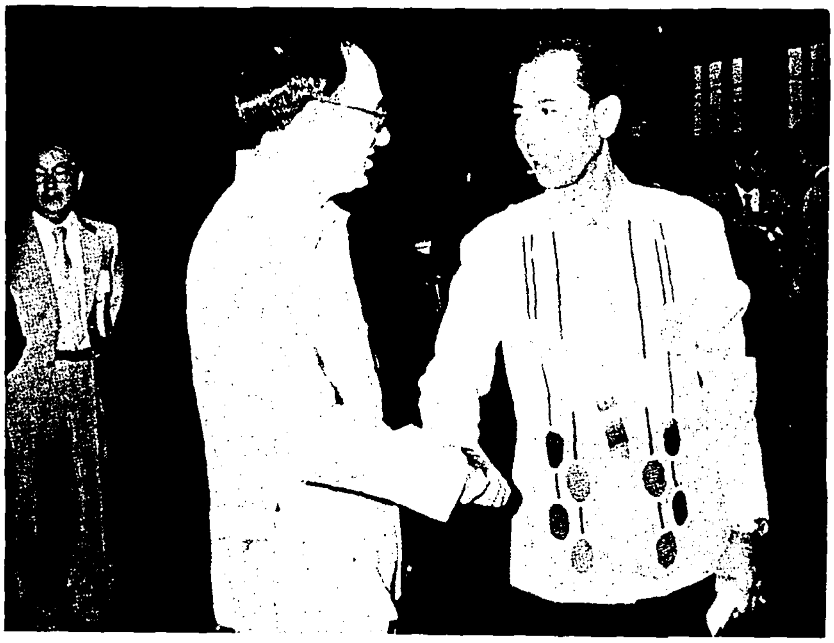
The Philippine International Convention Center – site of the conference.



The Opening Day. Foreign participants, particularly those from Japan, Republic of China and some Europeans, started arriving even as early as a week before the opening date. Others followed as the zero hour approached. However, the opening day still saw hundreds flocking to the registration booth. For a while, the organizers wavered a bit as they gallantly coped with the unexpected number of delegates, foreign and local, that kept coming in. As if that wasn't enough, the hosts, too, had to worry over the proper reception to be accorded the great personages expected to grace and usher in the occasion — the First Lady herself, Madam Imelda R. Marcos and accompanied by no less than the Prime Minister, Cesar E.A. Virata and the Minister of Public Works and Highways (MPWH) Jesus S. Hipolito. With determination and sheer guts, the organizing committee and the staff showed the winning attitudes that they sustained throughout the affair — grace and composure under straining pressure. Aside from a little adjustment on the time schedule, the opening ceremonies went smoothly well with the First Lady giving the keynote address, officially declaring the Conference cum Exhibition open. The rest of the activities for the day followed suit; no snags, no hitches. Even the famous tropical Manila weather was at its pleasant best.



". . .the problem is not so much water supply, as it is the problem of how human beings look up and value the water supply situation. The solution is not providing human beings and human communities with the basic services and amenities for human living of which water is one and a beginning, as we concern ourselves for human kind's fulfillment."



Above:

Some of the local delegates registering before the opening ceremonies.

Left:

Philippine Water Works Association (PWWA) vice-president for National Affairs Carlos C. Leaño, Jr. greets a European colleague.

Below:

PWWA President Oscar Ilustre welcomes early arrivee Min. Jesus S. Hipolito of MPWH.

Above:

PWWA officials joined by IWSA President Maarten Schalekamp (in suit) in a huddle with PM Cesar E. A. Virata (with lei) and MPWH Min. Jesus Hipolito.

Center:

The First Lady, Madam Imelda R. Marcos receives a bouquet of flowers as she steps down from the official car.

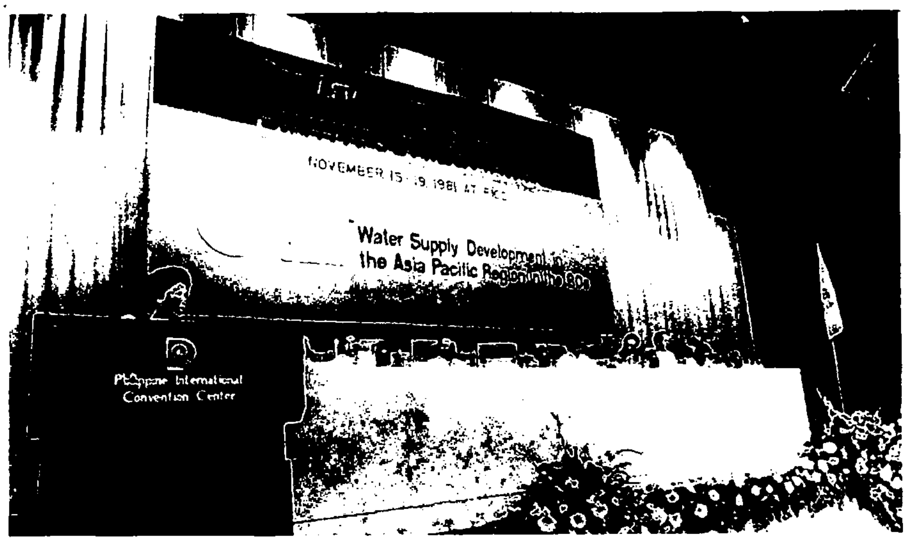
Below:

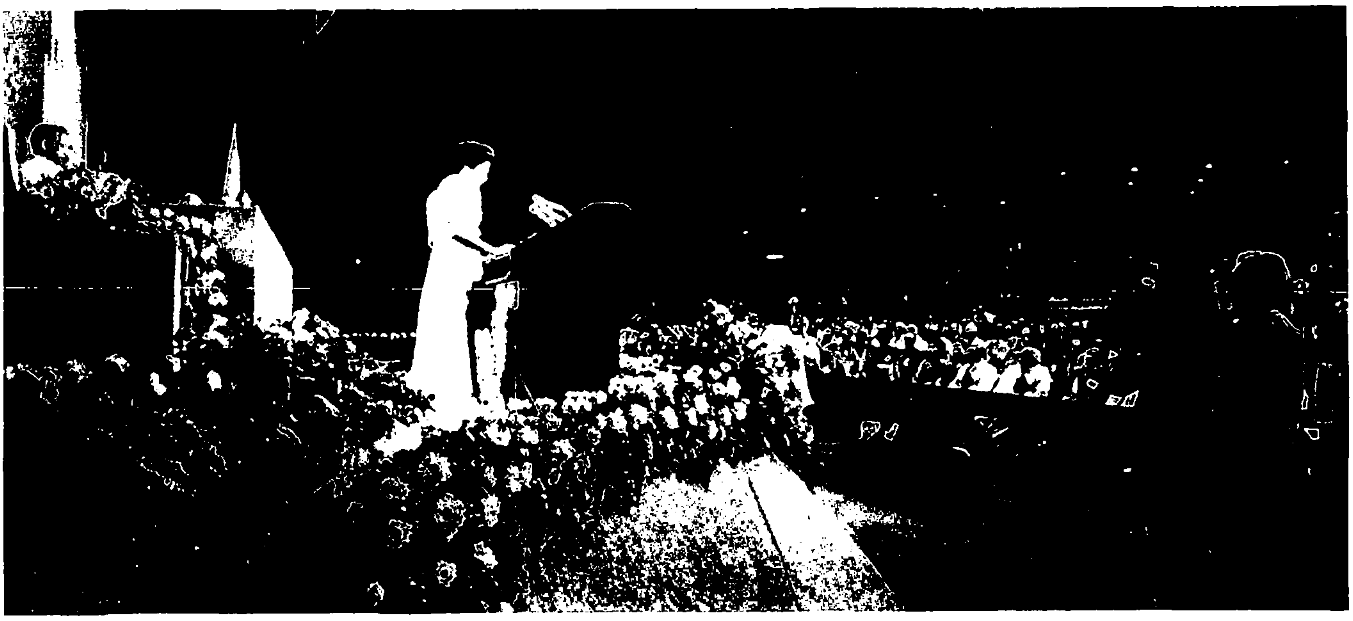
Mrs. Marcos being greeted by IWSA President Maarten Schalekamp who flew in all the way from Zurich for the occasion.

IWSA and PWWA officials escort Mdme. Marcos to the Plenary Hall.

The First Lady, Mdme. Marcos, flanked by Prime Minister Virata (R) and (L) Illustre and Ocampo, stands at attention during the flag ceremony.

The First Lady giving her message to the delegates and declaring the conference open.



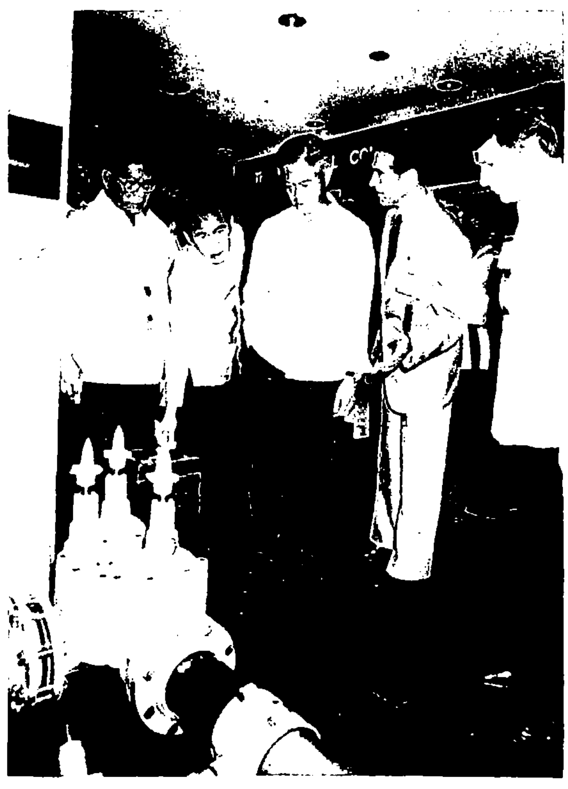


"LET US HOLD WATER SACRED, OR WE PERISH."

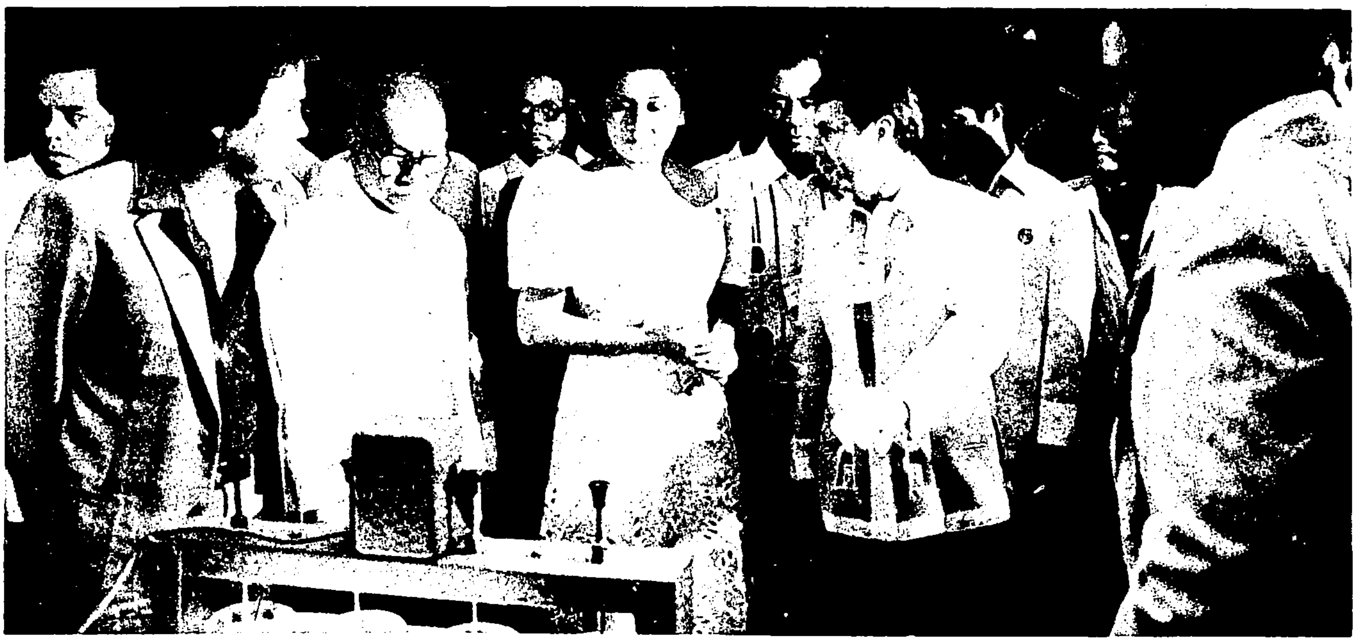
Exhibits. This was another new feature introduced in Manila to the regional water conference – the exhibition of equipment and materials, tested and new, to encourage more concern and awareness of the utilization of indigenous materials in water supply operation. The call to participate in the exhibition was well received by various people and producers involved in the industry worldwide. Several European and American pipe and water equipment manufacturers came and furnished the booths alloted to them with their latest products. Local manufacturers, too, eagerly participated that the whole exhibition site at the 2nd floor of the spacious Philippine International Convention Center was not big enough for the exhibitors. Some have to display their exhibits at the parking lot outside. It was no wonder then that the exhibition site was never without at least a hundred people at any given time during the entire conference staring in wonder at the conglomeration of water equipment gathered there – most of which they never saw nor even thought of before.

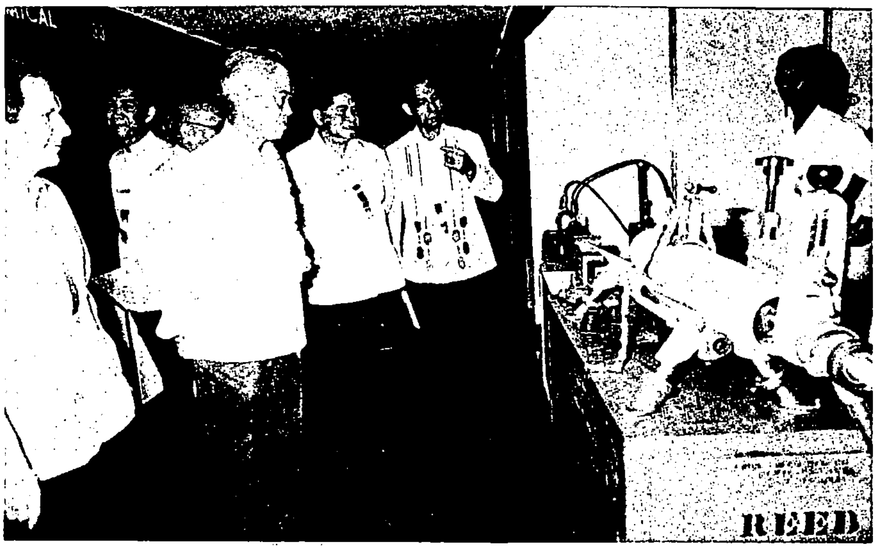
First Lady cutting ribbon to open the exhibits.

Madam tours the booths. With her are Min. Hipolito (partly hidden) Romualdaz Vildzius, Lamberto Un. Ocampo and Oscar Ilustre.

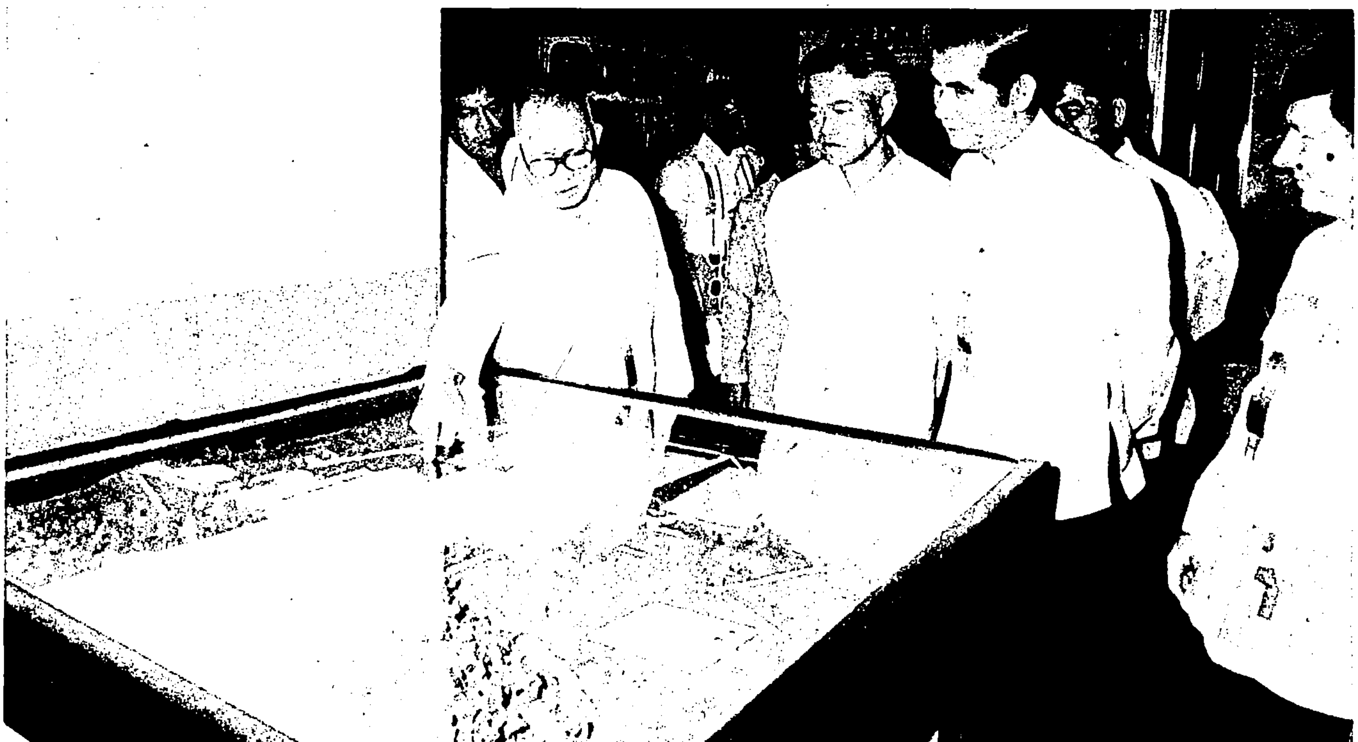


R. Vildzius (extreme R) chairman of the exhibits committee shows (from his right) M. Schalekamp, PM Virata, Min. Hipolito, and Ilustre the more sophisticated water supply equipment on display.





OFFICIALS AND GUESTS TOURING THE BOOTHS.

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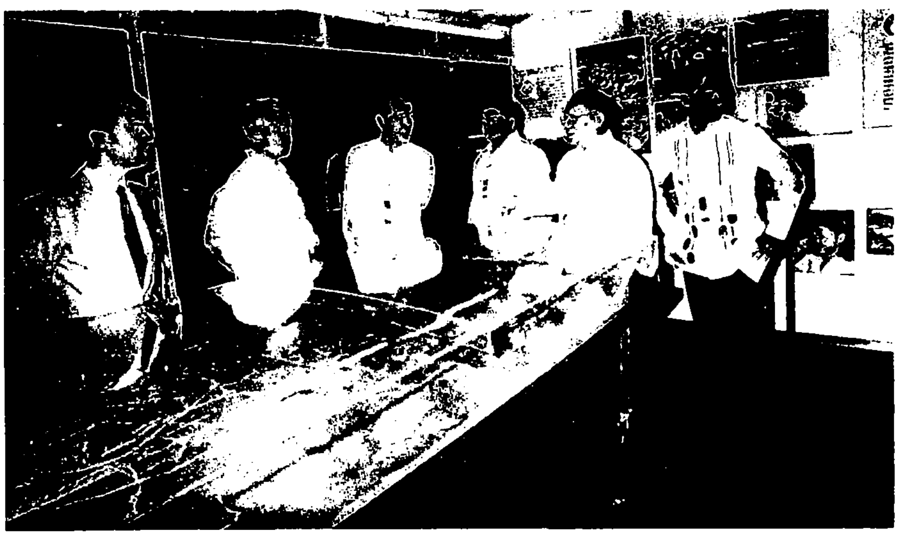


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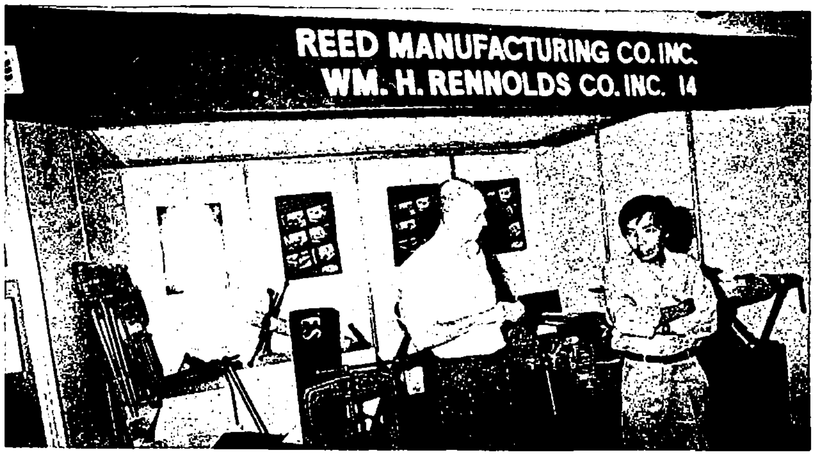
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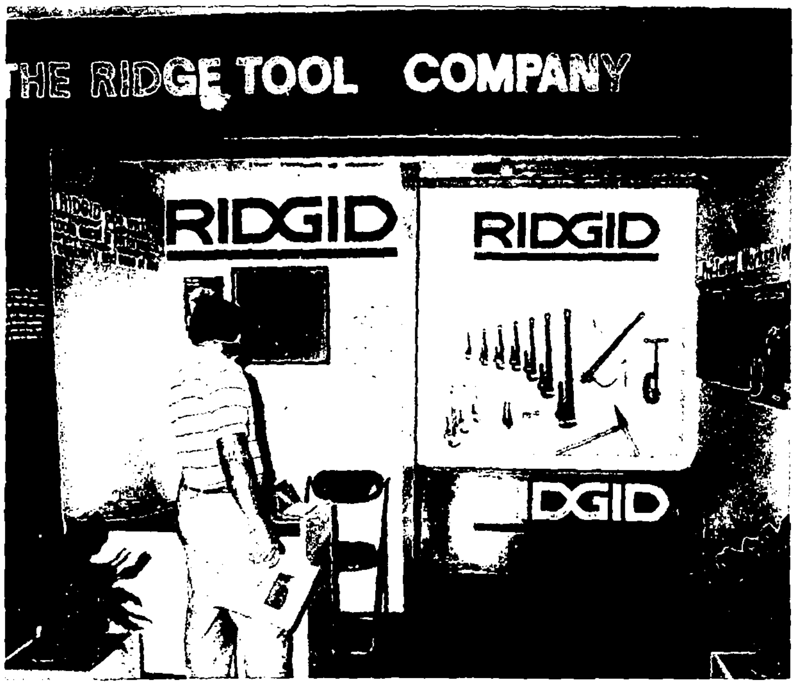
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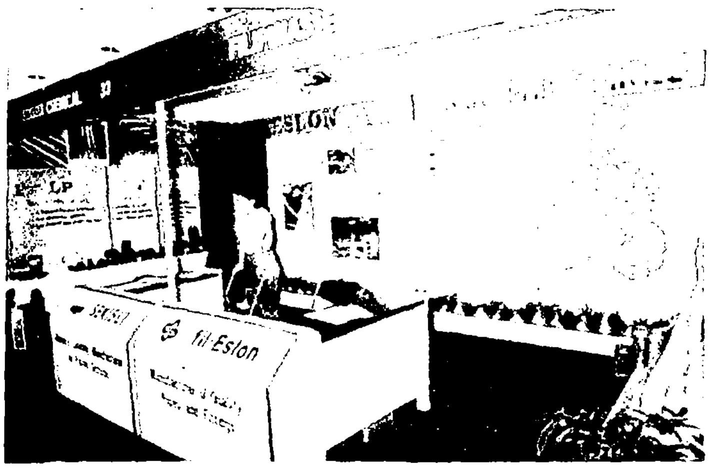
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The Technical Sessions in Brief. There were 42 technical papers, all of them authored ands presented by men of different color and creed yet bound by a single aspiration — the worldwide development of drinking water supply. They are all experts in the field, respected names in the industry. For the first time, they gathered together in Manila, to share their knowledge and expertise as well as to learn. To cram into a few minutes an idea or a technical process that has enough aspects to cover a whole week of discussion is no easy matter. But communicating with the fluid language of a people tied with the same aspiration and avocation, the presentors, if we may say so, successfully conveyed the message they brought along. Here they are, the men and their ideas and works.

THE TECHNICAL SESSIONS IN BRIEF

Innovative Experiences

Focused on the innovative waterworks development experiences of Thailand, Taiwan and Japan.

Vithya Pienvichitr (Thailand) reported on the remarkable improvement of Bangkok's water supply through the completion of the first phase of the Master Plan of the city's waterworks authority.

Osamu Tanaka (Japan) explained that new construction and extension of waterworks facilities are financed by loans from the government and private banking institutions, then consumers pay back the yearly installment and maintain the system.

Yung-ji Kou (Taiwan) discolsed that the country's industrialization and population situations are considered in the formulation of the general plan of Taiwan's water supply which involves too the development of water resources and all other aspects of water supply operations and management.

Delegates sharing expertise and experience.

Technologies for Developing Countries

The session dealt with potential technologies that can be adopted by developing countries from proper materials selection, to design and installation as well as concordant maintenance of the finished water system. Topics discussed include "Appropriate Materials Standards for Developing Countries" by Romualdaz G. Vildzius (Philippines) "Products Improvement in Pipeline for Water Systems" by John L. O'Brien (Australia), "Current Technology for Design and Installation of Steel Water Pipe in Japan" by Hirotsugo Matsumono (Japan) and "Treatment Technologies for Greater Taipei Area" by Ming Tsu Hung (Taiwan).

Operation and Maintenance

Carl Doran (US) read a paper on Pipeline Repair and Maintenance. Through the use of slides he discussed how holes of varying sizes in different kinds of pipes can be fixed.

Toyami Yamada (Japan) stressed that the block or zone system is preferable than the gridiron system which is most common in large cities. Many techniques for maintenance of the distribution system though are being currently developed, he pointed out, so choose what's best for your local situations.

Junji Tada (Japan) remarked that the most practical way to prevent leakage is to execute positive safe measures like reinforcement and replacement of old pipelines.

Romano Colla of Italy was supposed to talk of his country's experiences in Water Line System but he wasn't able to come around for the conference.

Water Treatment

A lot of natural impurities such as metallic elements as lead and mercury, organic compounds as pesticides and herbicides pollute water which could result to diseases and even death.

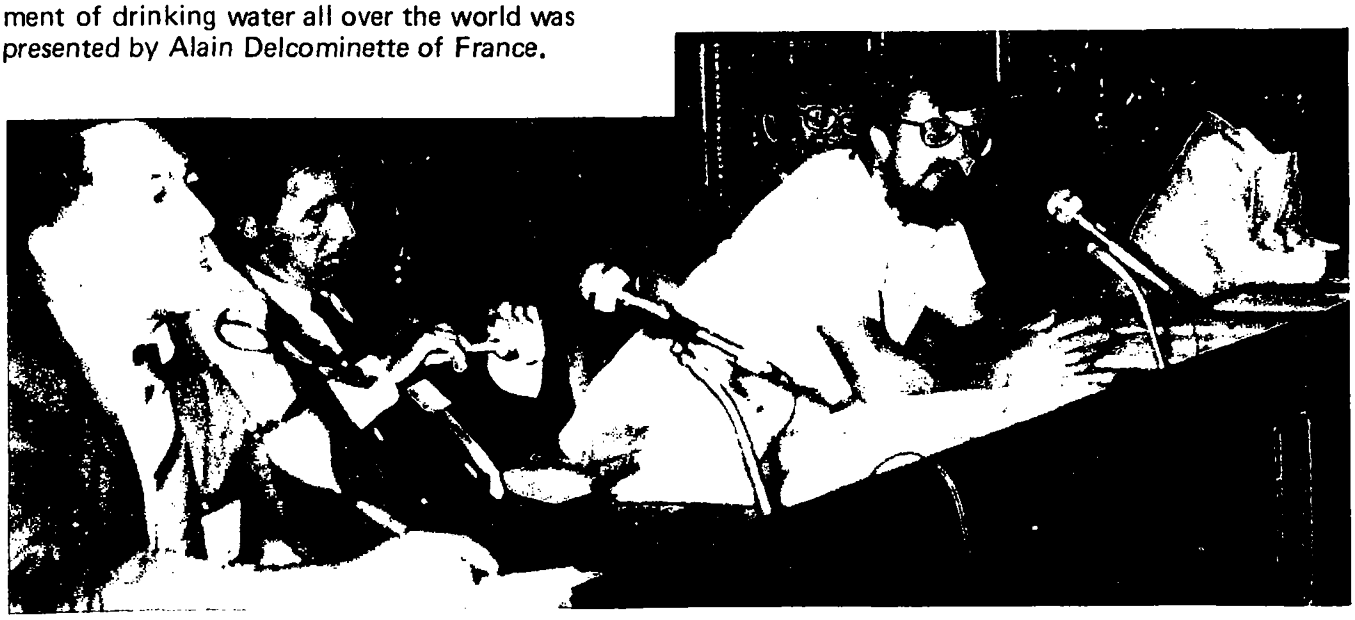
Hence, there's a need to repurate raw waters to allow their safe delivery to end users.

Japanese engineers Atsuhisa Sato and Koki Goto discussed "Comprehension and Mechanism of Alum Sludge Under Constant Pressure" while J. C. Huang and S. F. Shu from Taiwan reported on "Chemical Conditioning, Thickening and Dewatering of Poly Alum Chloride Sludge."

French water expert Jean Mignot, who was invited by the MWSS to install a pilot station at the Balara filtration Plant in 1975, reported on "Modern Surface Water Filtration Techniques Applied to Manila Water."

The technology on the removal of algae from potable water was discussed by Yung Kyu Park, Chue-Heui Lee and Su-Won Kim of Korea.

The applications of ozone to the treatment of drinking water all over the world was presented by Alain Delcominette of France.



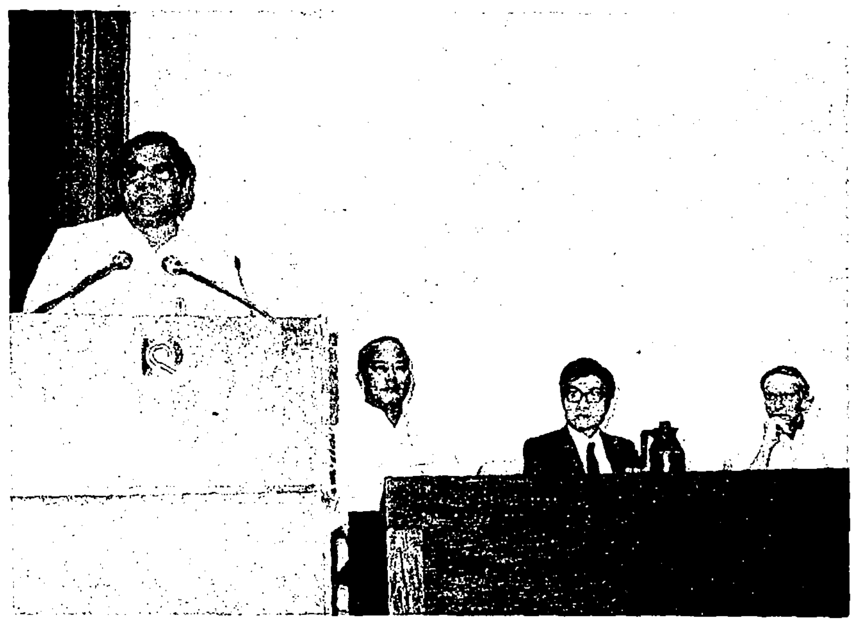
Metro Cebu Case Study

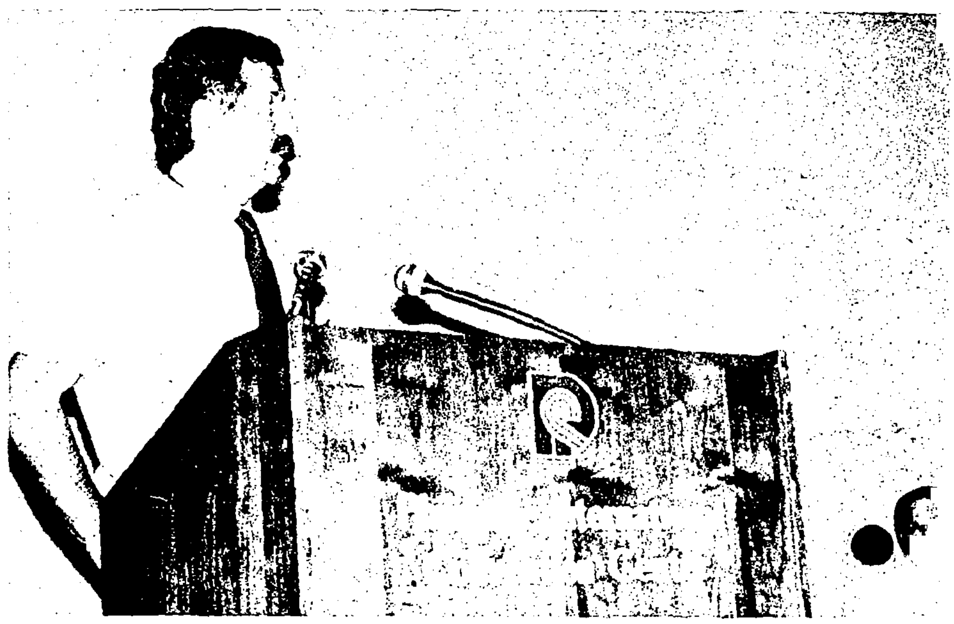
Cebu the 2nd biggest city of the Philippines is all out to keep itself the Queen City by the development of its water supply to the fullest possible, Alfredo Veloso of Metro Cebu Water District said.

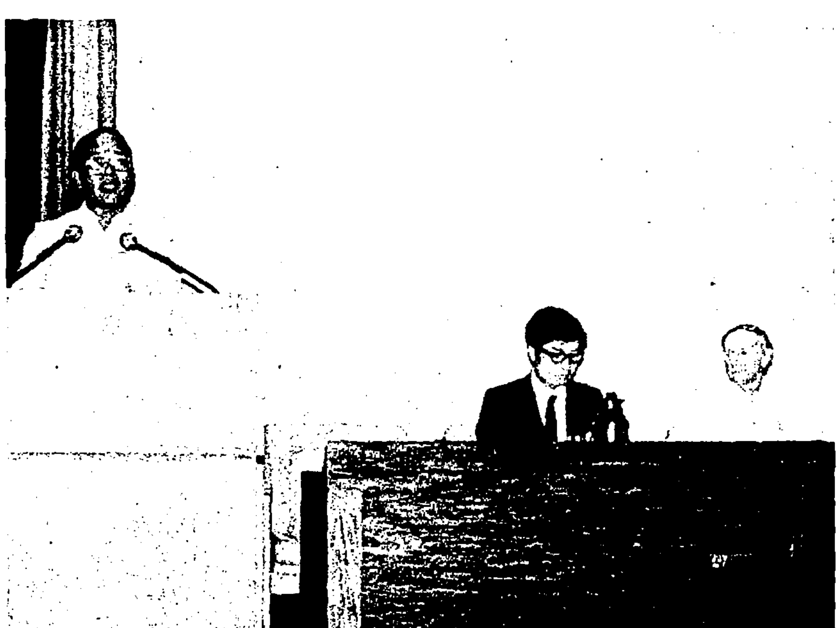
Stuart Menzies (Denmark) one of Cebu's foreign consultants, described the hows and whys of the district's interim improvement program.

Gerald Franzman (West Germany) another consultant discussed the magnitude of the city's biggest project so far, the Lusaran Dam, which is expected to be the long lasting answer to Cebu's water supply problem.

But the city need not depend on the dam as the source of water supply, Zvonimir Haman (Denmark) averred. Cebu's groundwater sources are still very much adequate and usable with the help of proper technology.

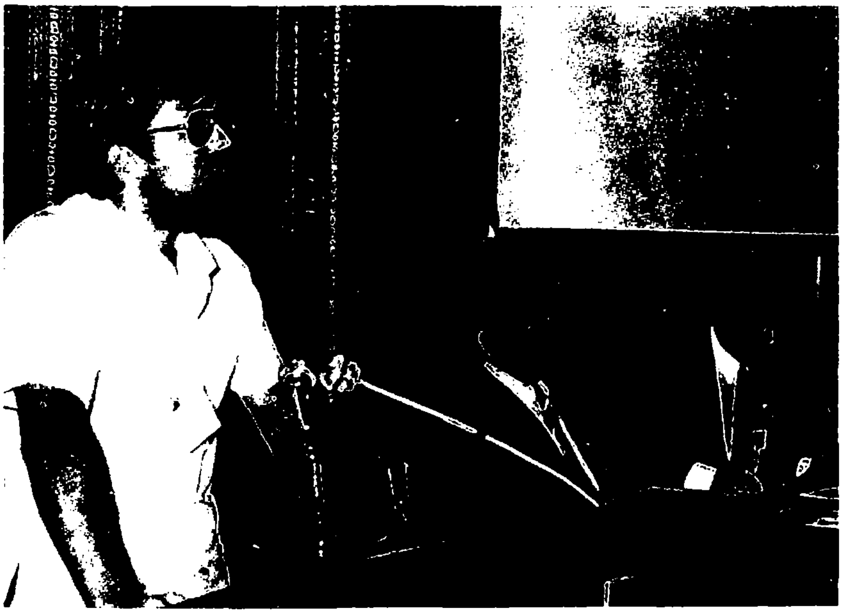






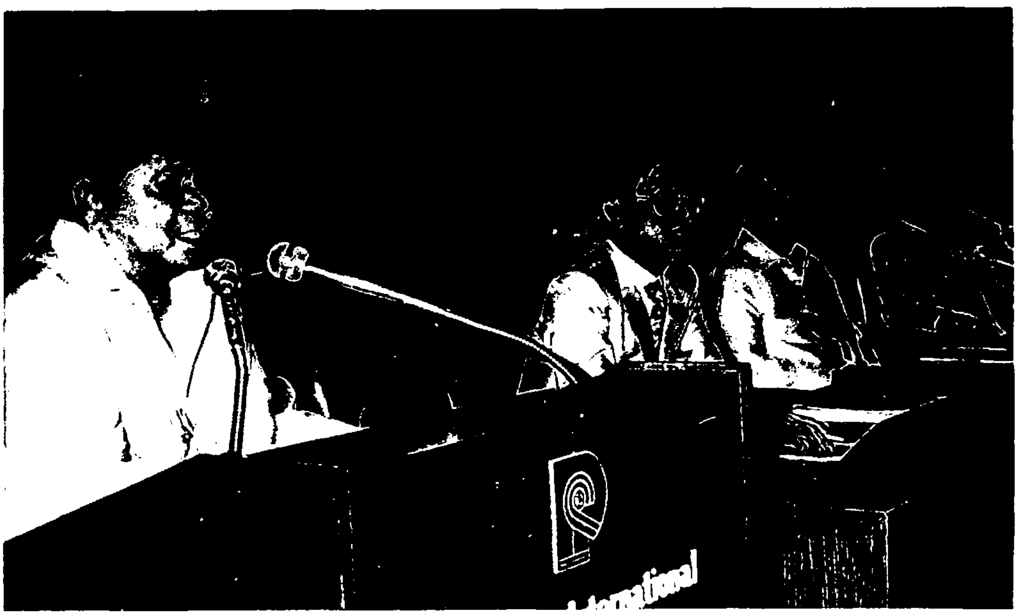
Urban Water Supply Projects

Three Asian water experts, Marcial Manalaysay (Philippines), Chung Hyen Park (South Korea), and Teng Yung Lai (Taiwan) discussed how their respective water authorities will meet the herculean task of supplying the growing water demands of their countries' capitals.



Commentaries from Special Institutions

Edwin Lee of the World Health Organization talked on the Water Decade and the rationale and goals of the program while three other financial experts, David Howarth (ADB), Klas Ringskog (IBRD), and William McDonald (USAID) discussed the financial and institutional aspects of operating a water system.

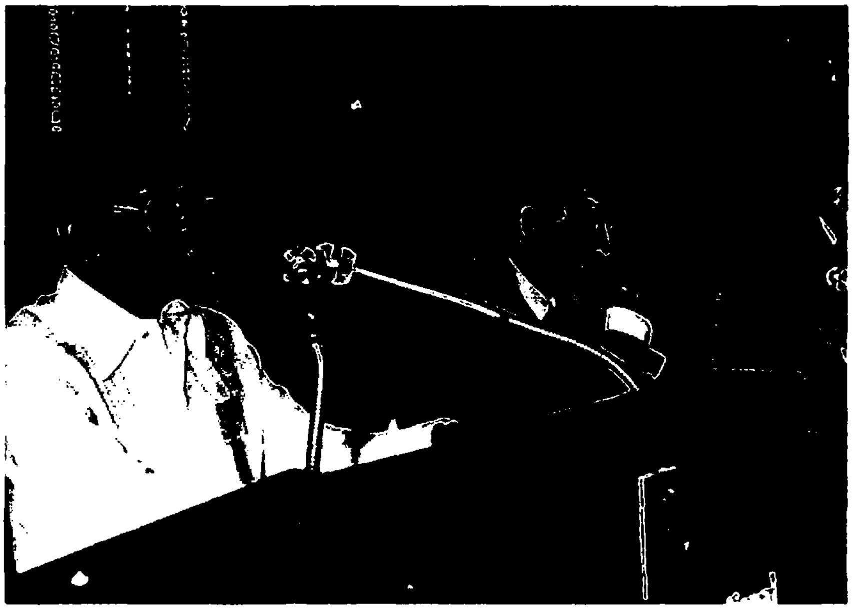


Role of Consultants

The hiring of Consultants, whether foreign or local, can be a big help to projects in waterworks development but problems can arise, too, in the process. Two consultants, William Caroll and William Aultman (USA) discussed about foreign consultants and Lamberto Un Ocampo (Philippines) on the other hand talked from experience about problems that may come out from hiring consultants Primitivo H. Alava and Teofilo Asuncion (Philippines) co-authored a paper that dealt on the problems that may arise from hiring consultants, from the client's point of view.

Project Planning and Development

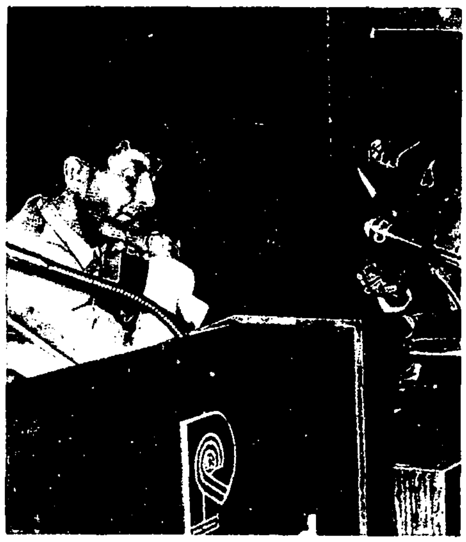
Economy on time and manpower as well as funds can be achieved in waterworks projects through proper planning, simplified design and adoption only of projects based from the real needs of the community. Jack Scheliga (USA) talked on water sources in relation to FS and Design Activity; Emmet Lowry (USA) on "Design Methodology" and Cesar Yniquez (Philippines), "Project Concepts for Low Cost Programs."

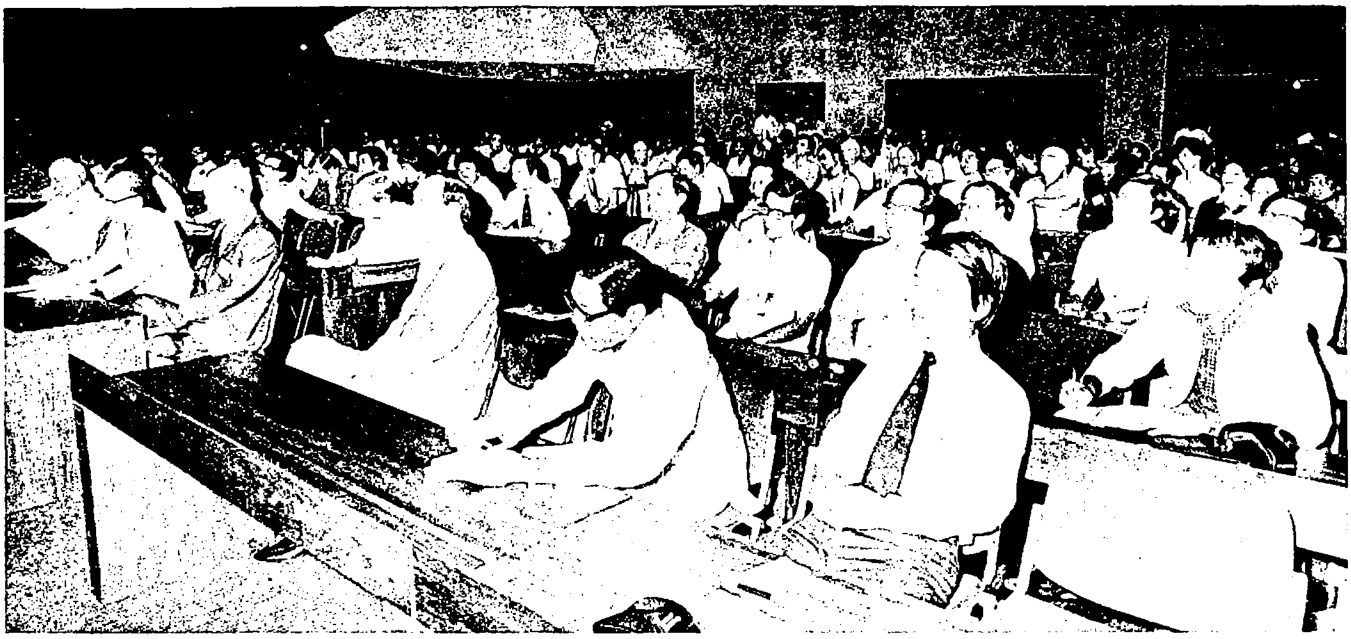


Rural Water Supply Development

They may just be simple and relatively cheap but rural water supply projects can just as well be the biggest and most important part of a country's over-all water supply scheme, or the world's for that matter, due to their impact on the larger number of people.

Luis Cerrafon (Philippines) and, Paul V. Hebert (USA) tackled separately the more important aspects in rural water supply development including problems that could be encountered.





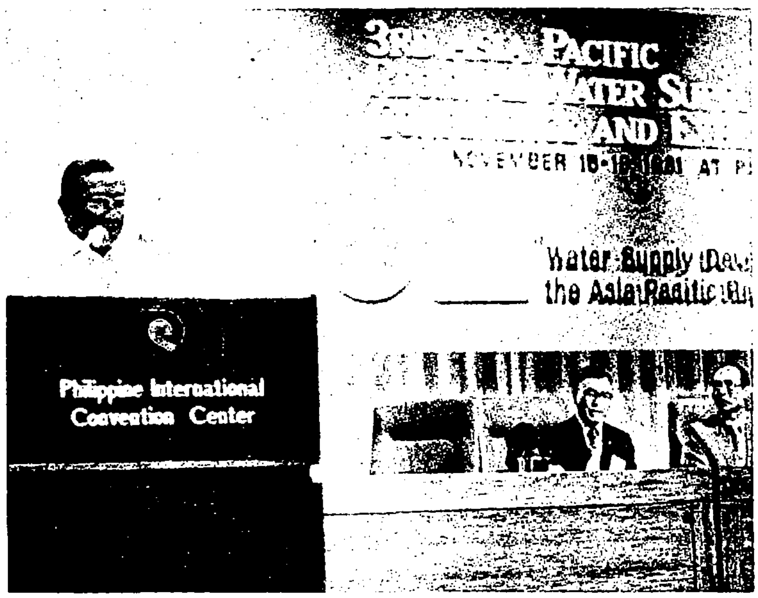
Revenue Generation Strategies

Discussion on ways by which income can be derived from the installed water supply system.

Ibarra J. Olgado (Philippines) discussed on the "Marketing and Information Strategies for Water Utilities," giving emphasis on the importance of Public Information addressed to people and institutions to get their full support and cooperation.

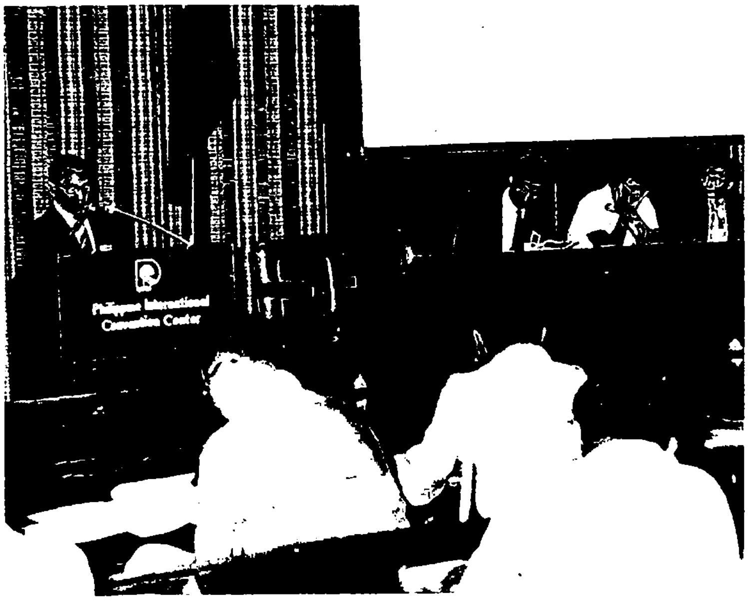
Felix Bruppacher (Switzerland) presented the "Marginal Pricing Approach to Water Rate Development."

Ricardo T. Quebral (Philippines) presented a paper on "Minimizing Unaccounted for Water" where he cited the millions of gallons of water from which no revenue is derived and where the government may generate millions of pesos should this wastage be minimized.



Water Resources

The last of the sessions tackled the part where every waterworks system begins – water resources, and that involves "Drilling for the Resource, Philippine Experience" by Joseph T. Callahan, (USA); "Developing Data Banks," Zvonimir Haman (Denmark); "The Importance of Gathering Groundwater Data by Operators" Herminio Bautista (Philippines); and the "Allocation of Water Rights," Jesus de Leon (Philippines).



Choice Cuts

– HIGHLIGHTS & SIDELIGHTS

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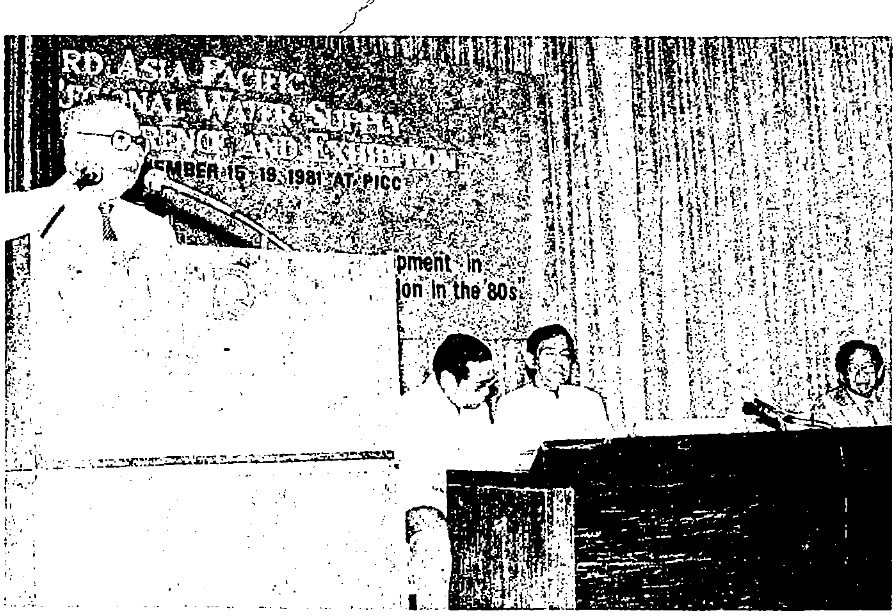
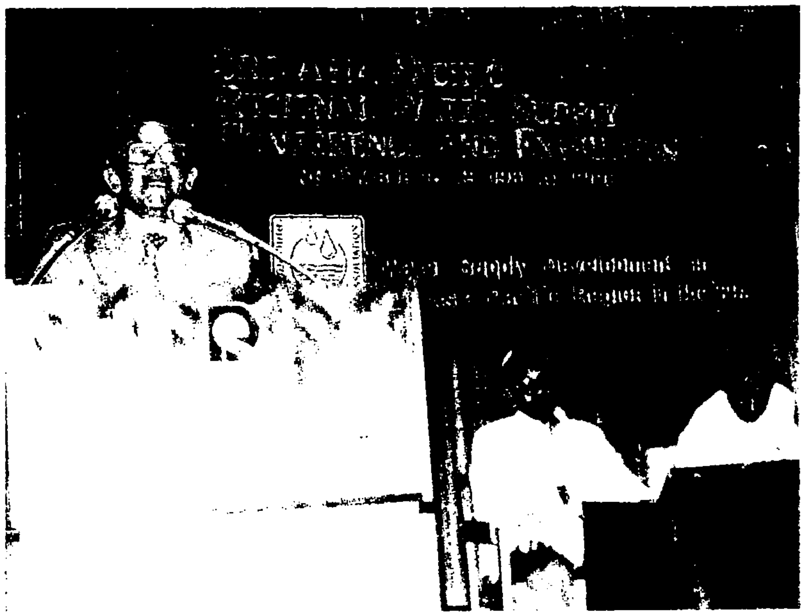
Carlos C. Leaño, Jr. recapitulating the conference's accomplishment during the plenary session.



A word from the chairman of the conference, Oscar I. Ilustre.

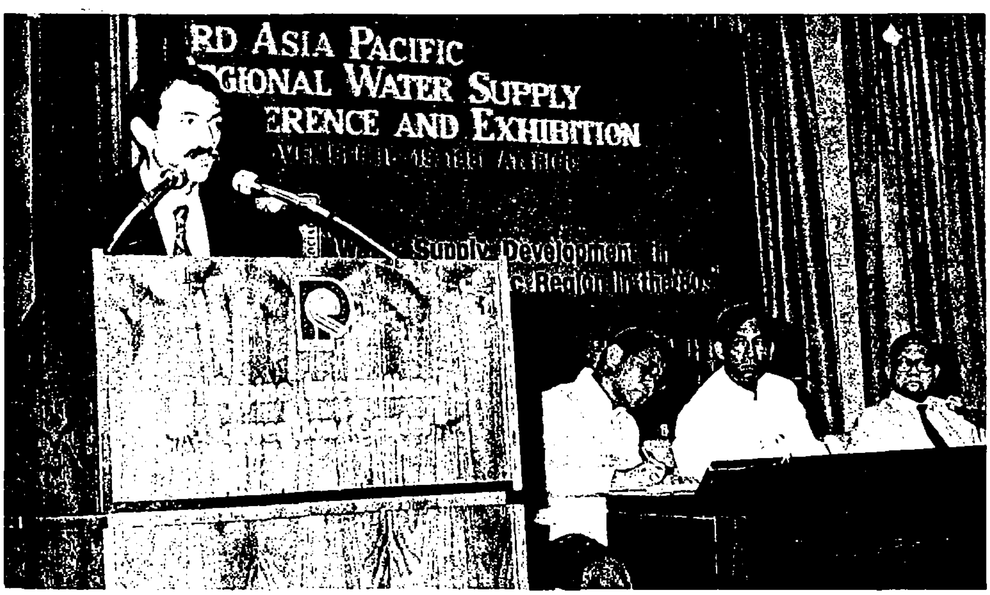


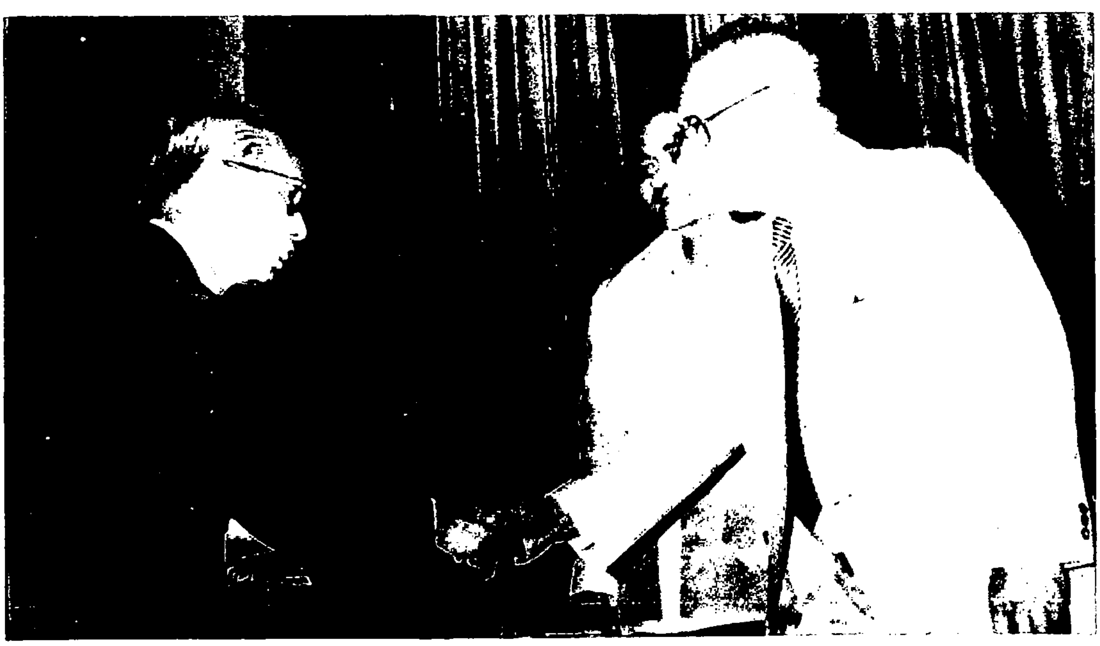
And from the incoming chairman of the 4th conference to be held in Djakarta, Indonesia In 1983 – Hidayat Notosugundo, Indonesia.

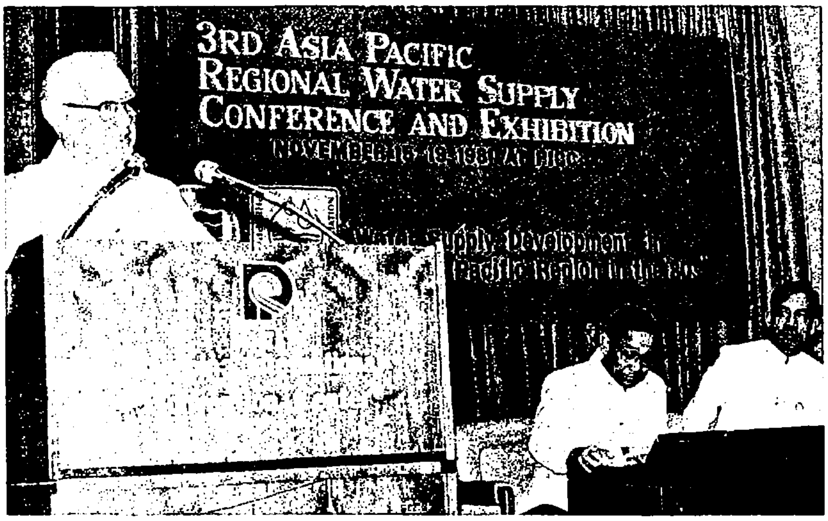
Ilustre shakes the hand of Notosugundo after the presentation of the gavel symbolizing the Indonesian's chairmanship of the next conference.

Ilustre & Notosugundo acknowledge the applause of colleagues.

And messages too, from the presentors of technical papers and heads of delegations after their reception of certificates and souvenir PWWA banners.







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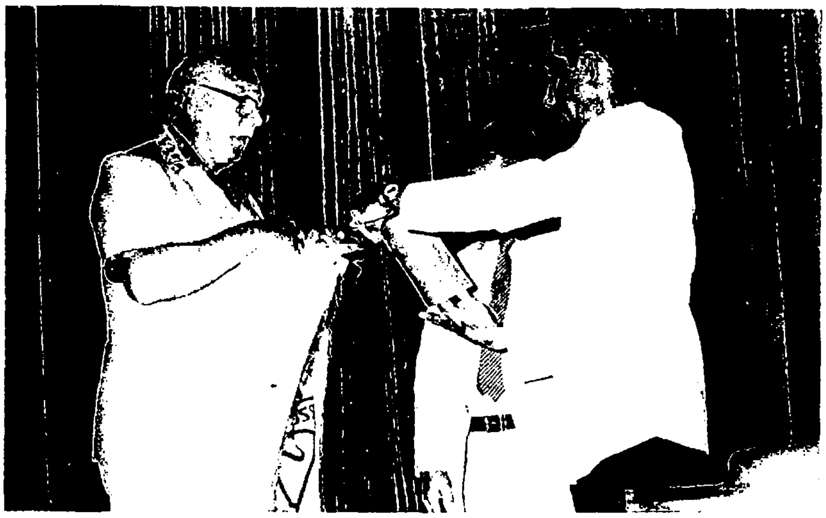
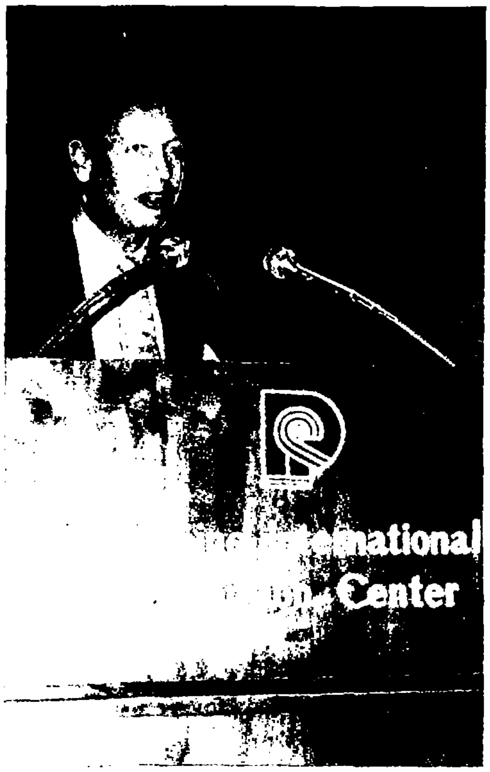
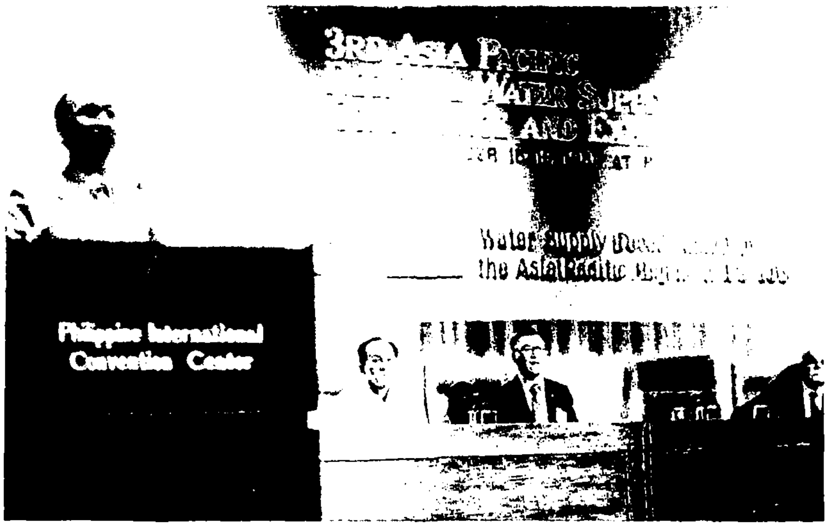
SESS  ION THE PLENARY SESSION THE PLENARY





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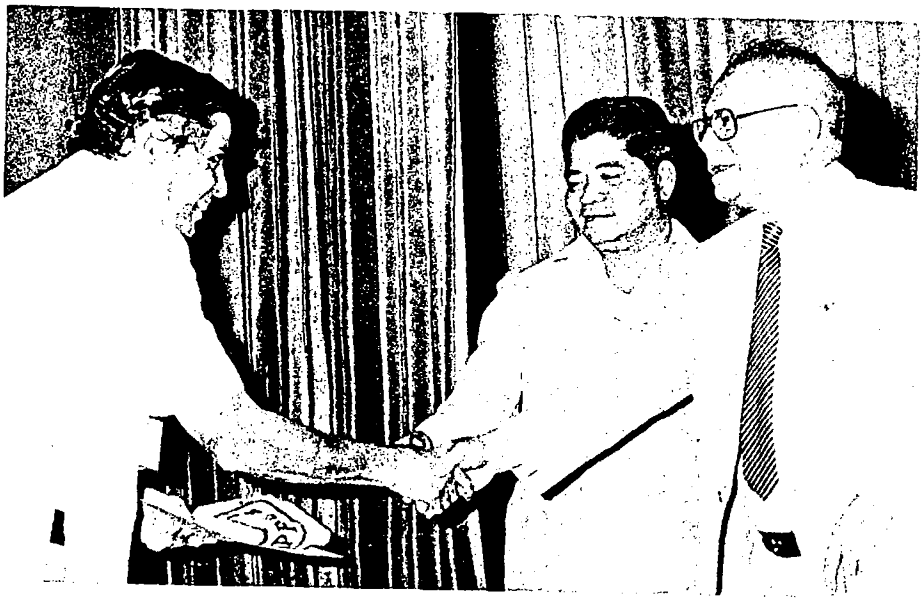

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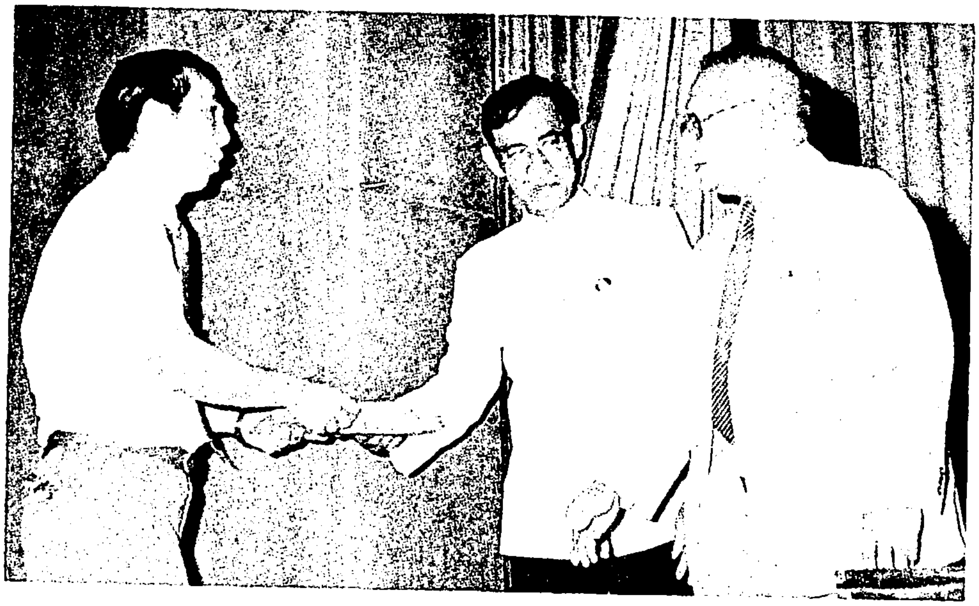
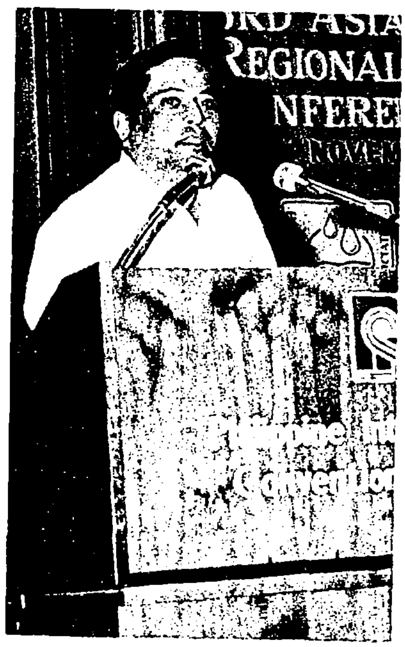
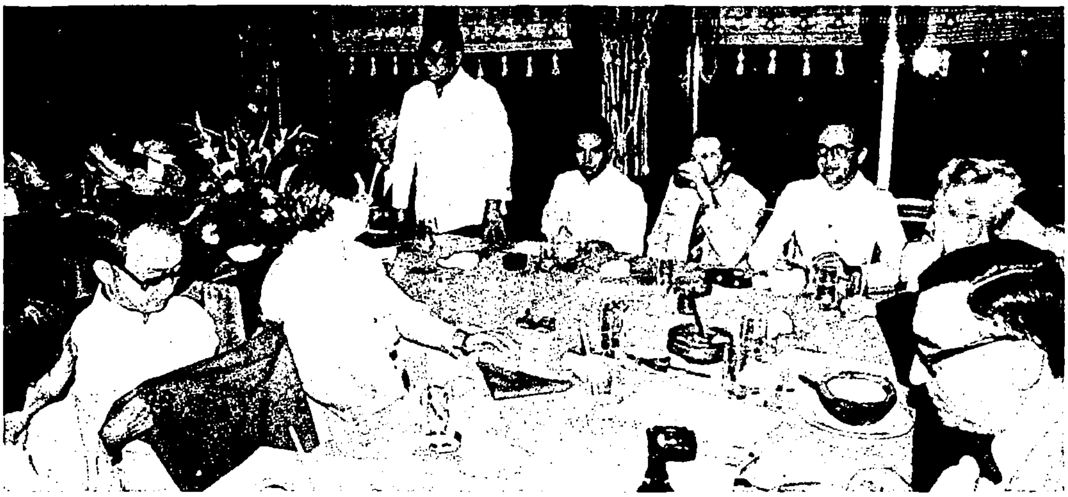
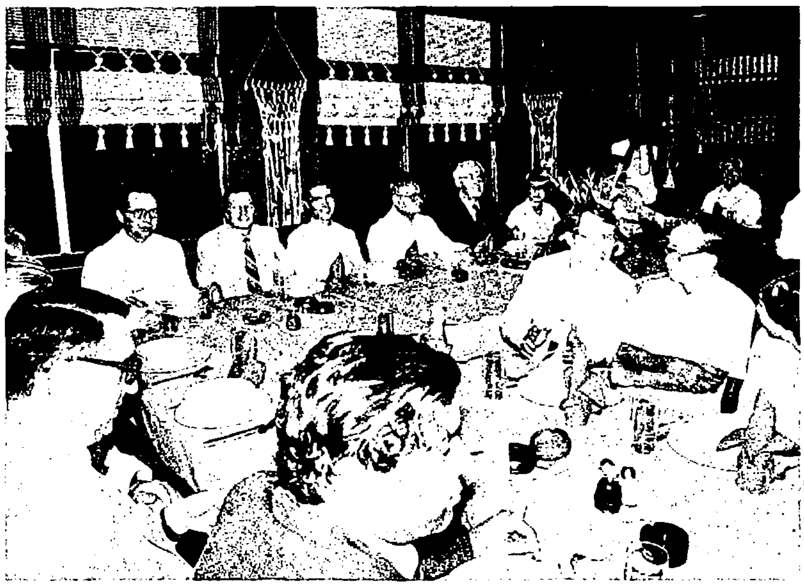


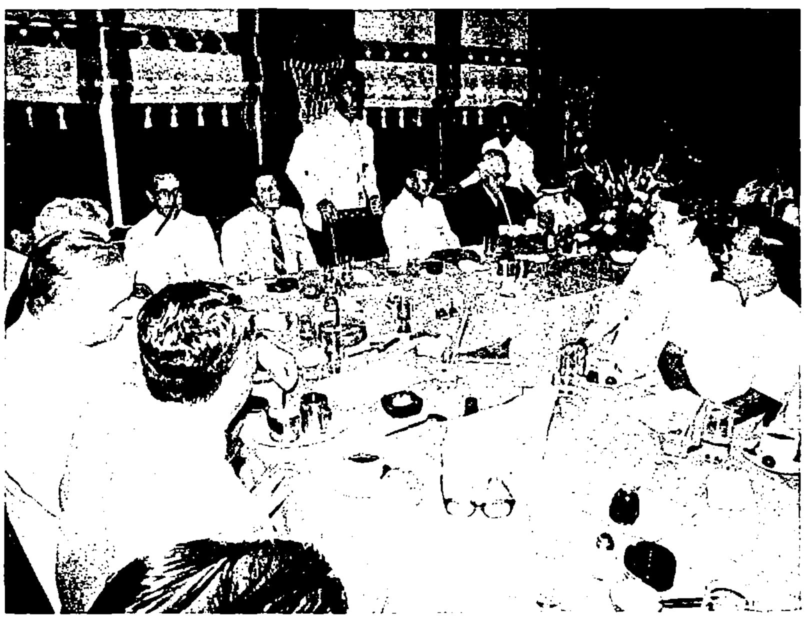


EAST ASIA REGIONAL GROUP MEETING WITH IWSA PRESIDENT AND SECRETARY GENERAL.

LUNCHEON WITH THE IWSA PRESIDENT, MAARTEN SCHALEKAMP







GETTING TO KNOW YOU AND SOME . . .

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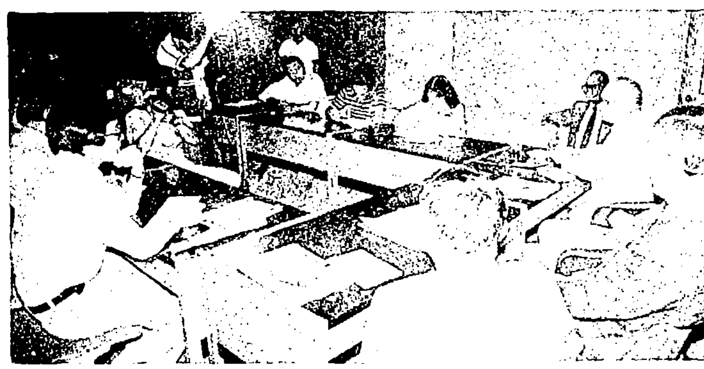
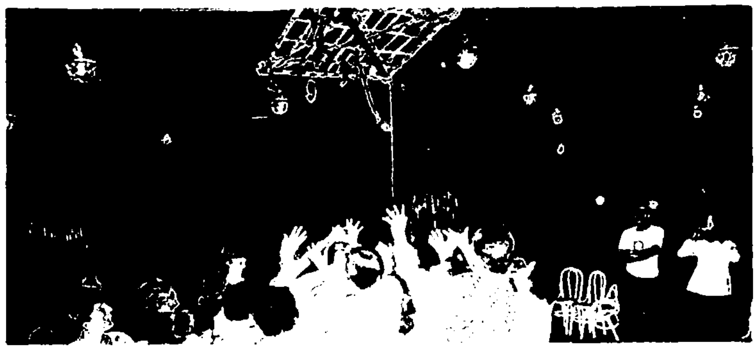
TALKS WITH THE PRESS



A TASTE OF PHILIPPINE BARRIO FIESTA



Pabitin . . .

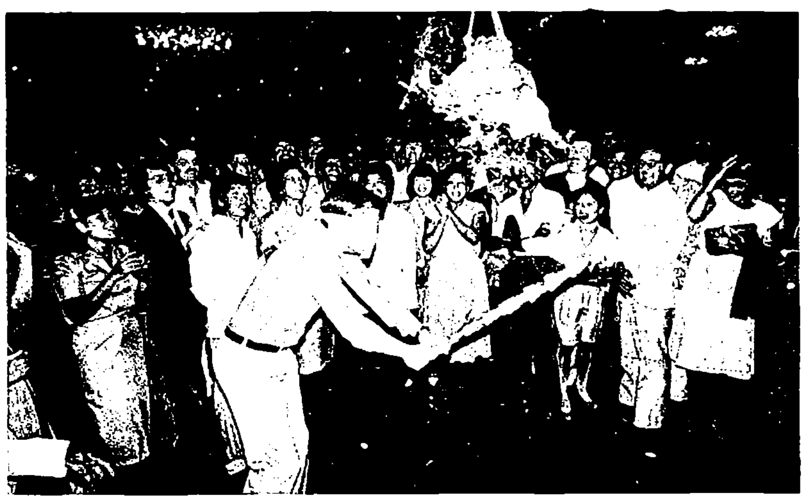
Dancing the tinikling . . .

. . . and the Pandanggo.

Breaking the pot . . .

. . . and scrambling for the prize.

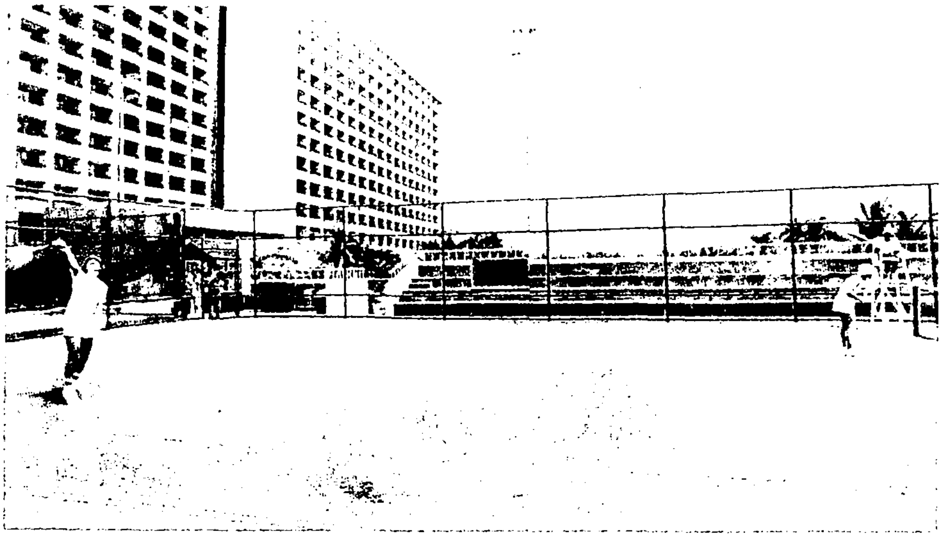
Savoring Philippine caviar.



"Got it!"

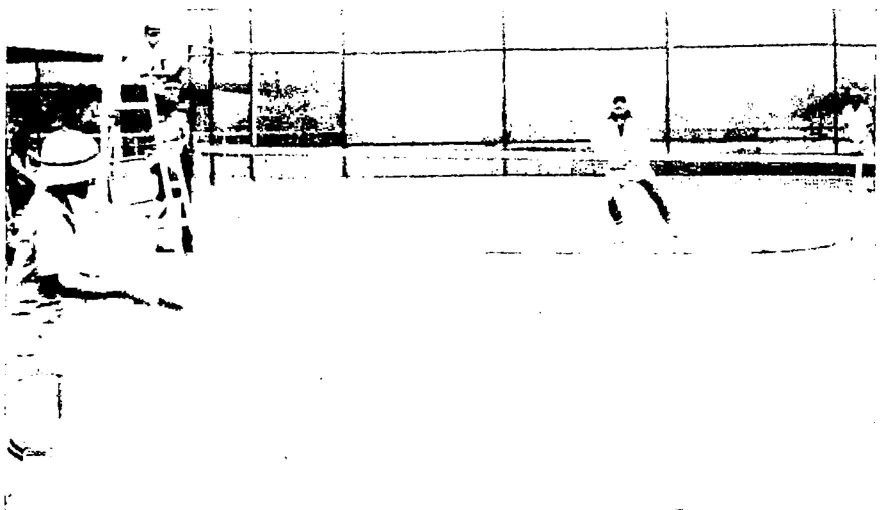
SPORTS ACTION – PHILIPPINE PLAZA TENNIS COURT

Father and son tandem.



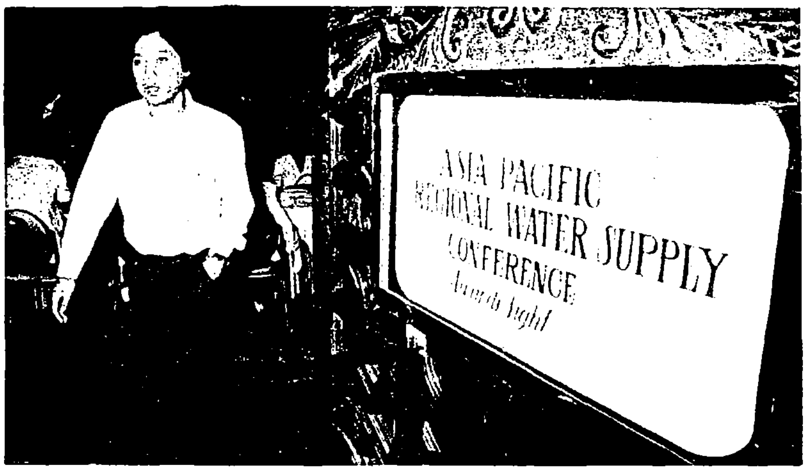
Mixed doubles, not a drink on court. It's a game between he and she pairs.

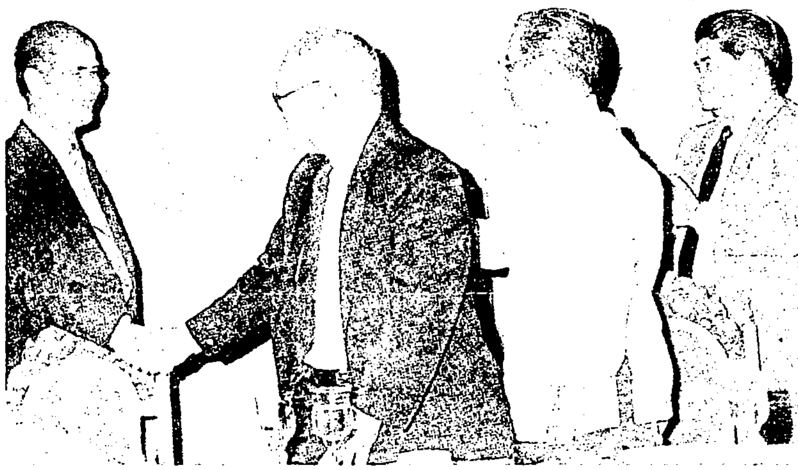
Hardcourt ballet.



"Watch it, Grandpa!"

AWARDS NIGHT AT THE MANILA HOTEL: NOV. 18, 1981, 7:30 P.M.





Min. Jesus S. Hipolito, MPWH, Awards night's guest of honor being greeted by Ilustre, former MPW Minister Juinio and Ocampo.

The presidential table.

Leaño introducing the guest of honor.

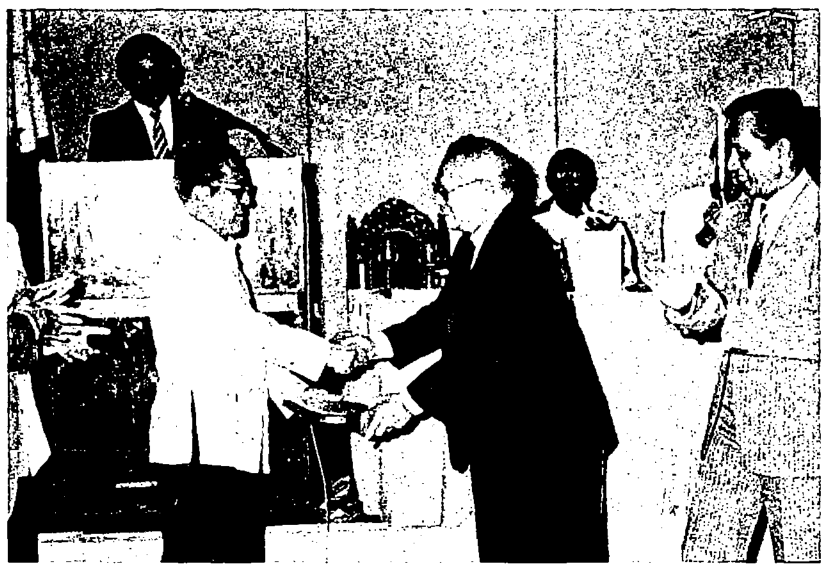
The guest of honor.

Min. Hipolito sharing a secret with Korean and Indonesian chiefs.

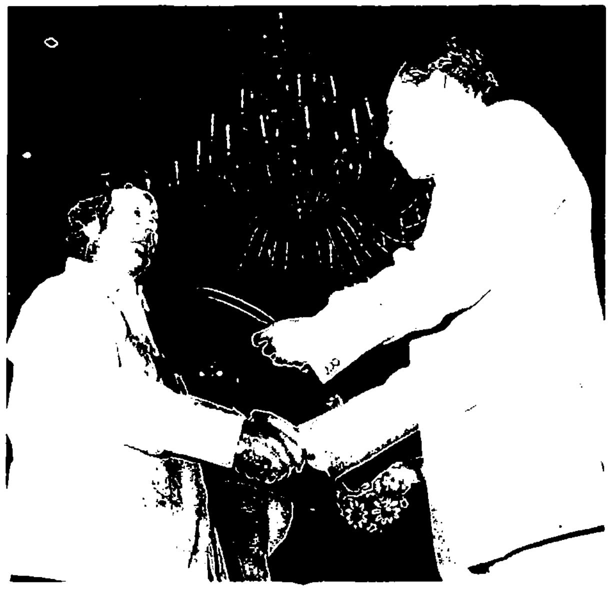
The party.

Hipolito receives plaque of appreciation from Ilustre.

And former MPW Minister Juinio, too.



And the rest followed. . .




Manila Hotel


Manila Hotel

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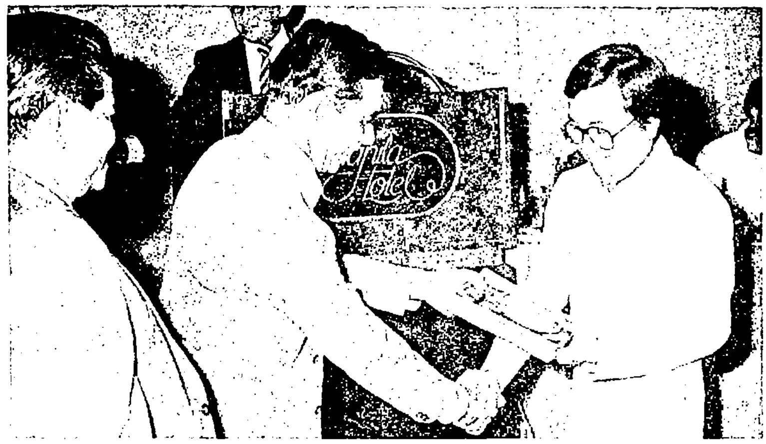

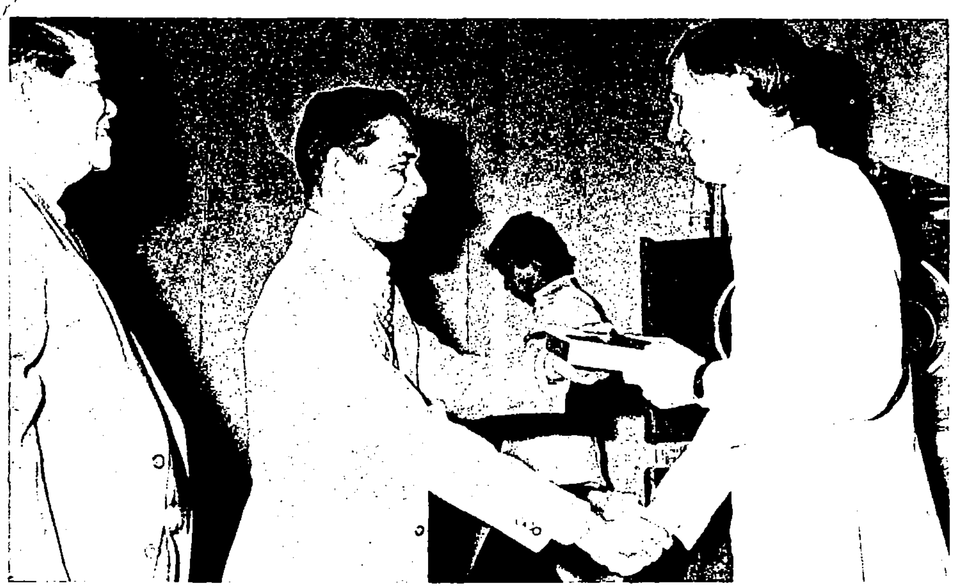

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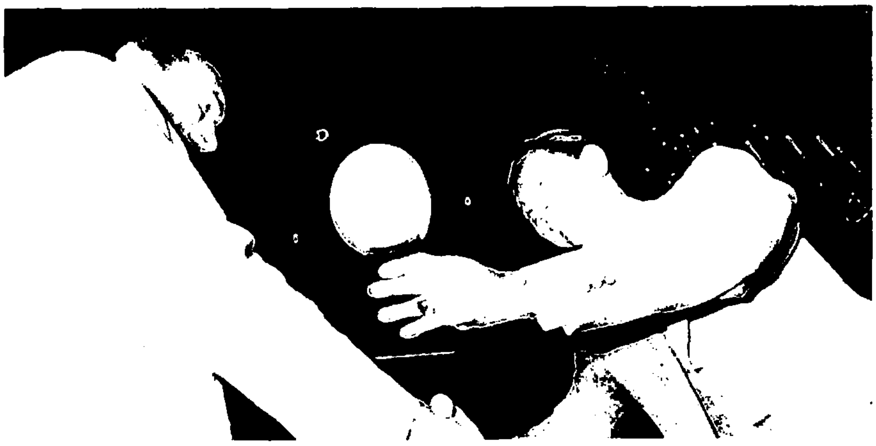

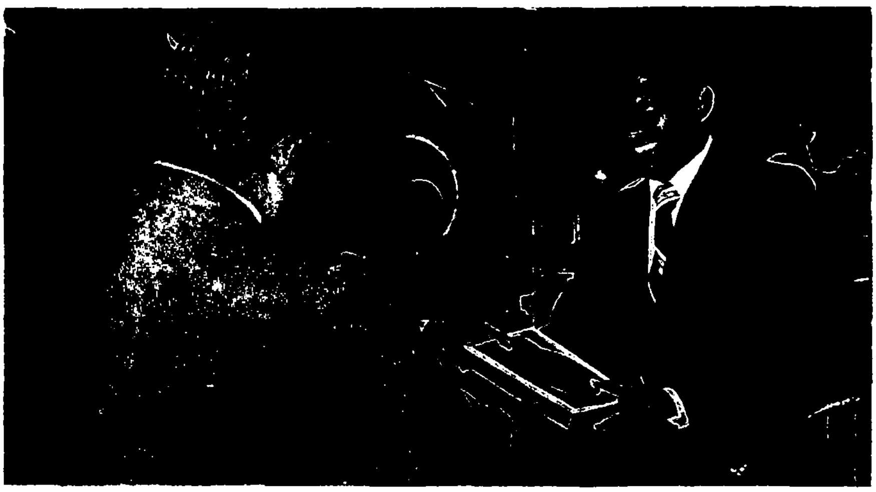

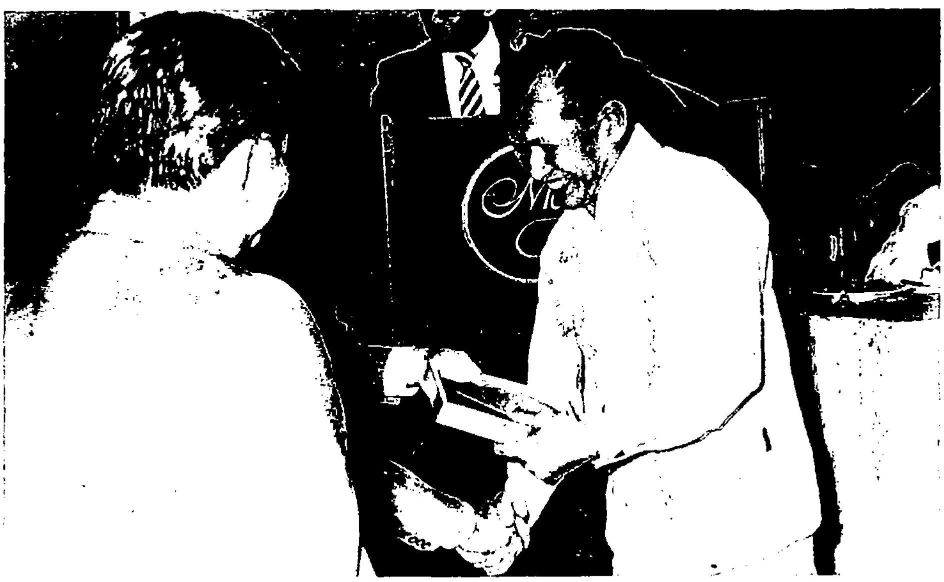

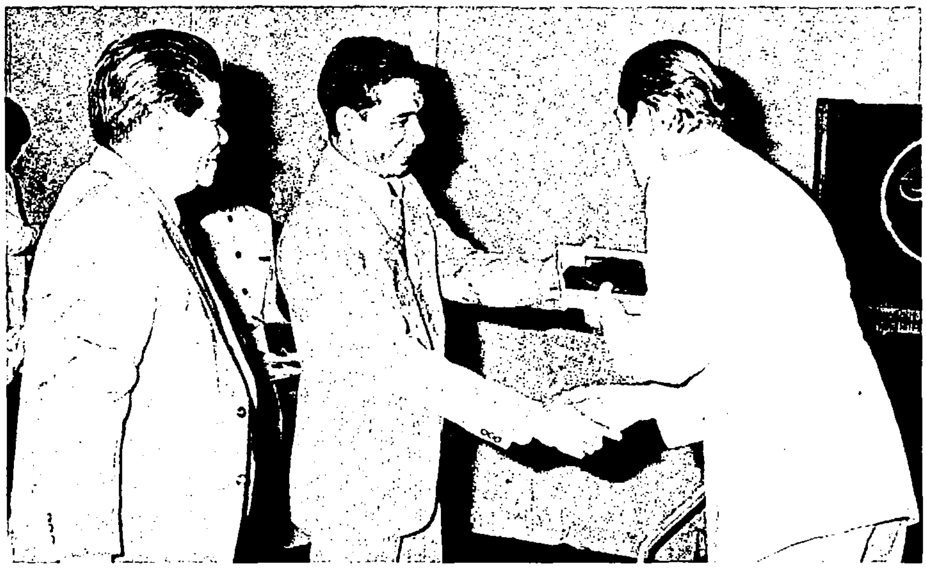

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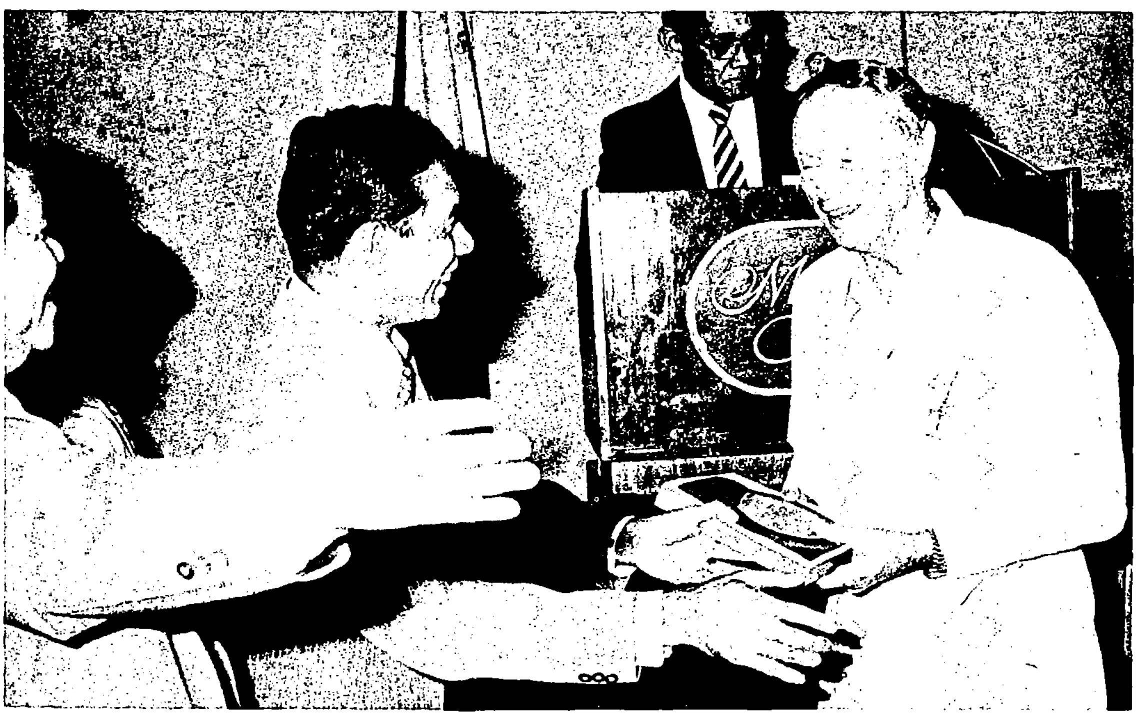
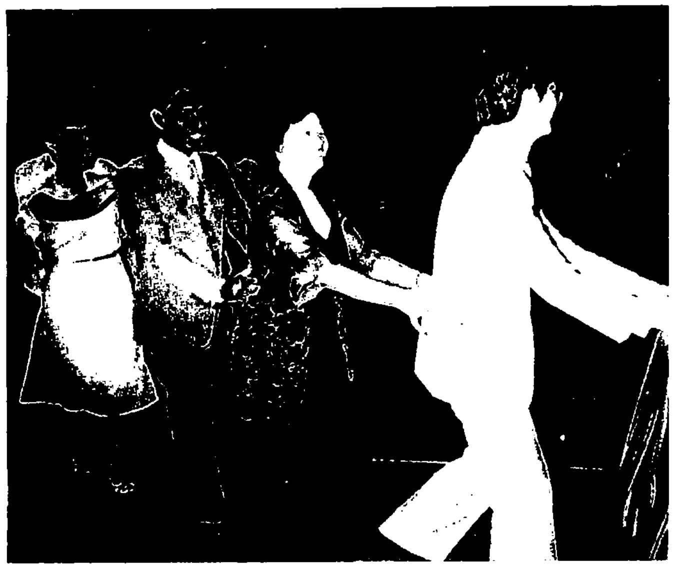




And do some dancing and singing, too.

The Organizing Committee. They are the men and women, most of the time faceless, who authored the great event, these members of the organizing committee. Coming from both the government and private sectors, these selfless persons who are in one way or another, involved in the Philippine water industry, unceremoniously joined together and formed the Philippine Waterworks Association to foster the development of drinking water supply in the country. And taking time out from their individual busy schedules, even to the point of cancelling important appointments or even perhaps losing a profit here and there, these men and women met regularly every month for a year to map out the course to be taken during the big event. With the way the conference went, their sacrifices were not in vain. Here they are, the brains behind the conference.

Oscar I. Ilustre
Chairman

Carlos C. Leaño, Jr.
Co-Chairman

Jose V. Angeles
Finance

Wilfrido C. Barreiro
Secretariat

Pedro G. Dumol
Operations

Romualdas Vildzius
Exhibits

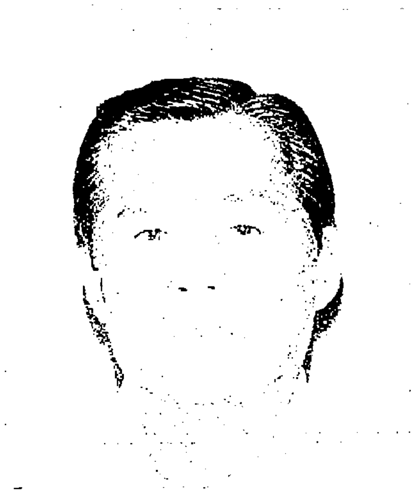
Consuelo E. Castañeda
Publicity

Norberto Luna
Transportation

Belen Ocampo
Food/Ladies Program

Lamberto Un. Ocampo
Participation

Rolando Roque
Invitations



Primitivo Alava
Socials

Jose Espiritu
Registration

Ricardo T. Quebral
Program

Tomas Carlos
Hall AV/Interpretation

Salvador J. Rivera
Technical Papers

Johnny Mercado
Awards

Other Committee Chairmen

- Felipe F. Cruz
  Sports
- Manuel G. Anonuevo
  Airport Reception