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Retrospective Review of Urban Operations

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TABLE OF CONTENTS

Page No.

TABLE OF CONTENTS (Cont´d)

Page No.

SUMMARY

1. This paper reviews the evolution and performance of urban operations in relation to the objectives established in 1972 and elaborated during the 1970's. The paper provides a cross-regional retrospective view of urban lending in order to assist newly regionalized urban divisions in formulating regional strategies for urban lending.

2. The Bank initiated an urban lending program in 1972 in response to requests for assistance in developing efficient and equitable approaches to the provision of urban services and the management of urban growth. Rapid urban growth in all regions of the developing world has placed enormous demands on public institutions which have lacked the technical solutions, institutional capacity, and financial resources to respond. The Bank adopted a research and development strategy, designing new low cost and affordable approaches in shelter and infrastructure which were intended to mobilize private savings and relieved the public sector of most of the financial burden for urban services. The elaboration of operational objectives associated with the new approaches has involved much debate and controversy within the Bank and among Borrower agencies. This debate has focused on issues such as whether Bank urban lending should address urban development or urban poverty as a primary focus or how sub-sectoral projects in shelter, infrastructure, and transport contribute to management of the sector as a whole. The diversity of urban conditions and policies across the regions has supported the conclusion that individual operations have to be designed on a country and city basis as part of longer term sectoral strategies. Four general project types (shelter, transport, integrated urban and regional) have been developed in response to this diversity and tailored to respond to immediate problems within such a perspective. By 1981, some 62 projects had been approved, amounting to US$2,014 million in lending.

3. The projects financed by the Bank Group represented in many cases a sharp departure from previous investment policies in urban services. The novelty of the approaches and the difficulty of coordinating multiple agencies working within urban areas has led to implementation difficulties on initial projects in some countries. These problem areas have included institutional capacity, land acquisition and tenure, cost recovery, backsliding by project agencies towards higher infrastructure standards, project management, and experience with special components such as health and employment. Good progress is being made and subsequent projects are addressing these problems as local institutions gain experience with the new approaches. Experience with the 62 projects demonstrates the importance of a longer perspective on institutional questions, particularly in relation to the issue of replicability which is essential if programs are to be commensurate with the scale of urban growth. Nevertheless comparisons of urban project experience with other sectors suggest that delays in implementation have not created exceptional disbursement and cost overrun problems. Urban disbursement performance ranks sixth of nine sectors of Bank lending. Supervision reports indicate that most problems are resolved by the third and fourth year of implementation, although, as in other sectors, initial expectations concerning the pace of implementation are in some cases overly optimistic.

4. The paper also reviews the internal management of urban operations, which have grown from 10 professional staff in 1971 to 83 by 1981. The development of the Urban Projects Department over the decade has given the Bank substantial professional expertise in the sector. Over time, operations have become increasingly efficient, as the elapsed time in processing of projects is now significantly below the Bank average. Staff input for project processing varies according to project type, with urban shelter and transport projects close to the Bank average, while integrated urban development and regional development projects require substantial additional inputs. Coefficients in FY80 and 81 demonstrate that as experience is gained within the Bank and with Borrowers, urban operations increasingly conform to Bank norms. Economies in supervision are also occuring with multiple projects in the same country.

5. The retrospective review finds that Bank urban lending though modest in amount (it has risen to only 4.1% of total Bank lending by FY81) has had a significant impact on the way in which urban issues are being analyzed and solutions formulated and implemented. Specifically the paper examines the impact of urban lending on several aspects:

(a) National policy in the urban sector or sub-sectors

(b) Approaches to project design, planning, and investment programming

(c) Institutional development

(d) Policy and program impact in specific cities

(e) Direct project benefits, including poverty impacts

(f) Economic rates of return

(g) Impact in the Development Assistance Community

These impact have been substantial: policy changes are underway in more than 35 countries, appropriate project design has reduced costs in shelter and infrastructure provision by as much as 75% in many projects, and extensive direct benefits are being generated from projects. Some 1.9 million households or about 11.4 million persons have benefited from shelter projects alone. Seventy percent of all projects have large shares of total costs devoted to the urban poor. Estimated rates of return for all urban project types are high, with the FY81 average for eight projects at 21.9%. In qualitative terms, the Bank's urban activities are changing the policy framework and operational procedures for assistance to the urban sector in developing countries. Bilateral and multilateral donors are shifting their activities towards the Bank's approach to shelter and infrastructure provision, leading in some cases to co-financing of projects and a consensus on the objectives to be achieved in the sector.

6. The above achievements have to be placed in their proper context, however. As already indicated, problems in implementation remain and in some countries projects are only at the demonstration phase. In some cities initial projects have been single sector (e.g. shelter), are viewed as points of entry into the urban scene, and are now in the process of widening out to broader urban concerns such as urban management and municipal finance. Nonetheless, substantial momentum has now been generated by experience with the first decade of activity. More than 90 projects are under consideration and preparation for FY82-86 amounting to about US$4.0 billion in lending. This is evidence of both Borrower interest and perception that urban development is an integral part of the development process. Projects are proposed in about 50 countries, of which about half are new. The average proposed loan/credit amount is about US$45 million, with half of the operations expected to be below US$50 million.

7. The proposed program reflects growing awareness of urban development in developing countries and similarly growing credibility attached to Bank expertise. However, the contribution of the Bank's projects in relation to the size of the problem is small and can at best be catalytic. The major challenge, therefore, is to assist Borrower efforts to replicate successful project concepts on a programmatic basis. Experience has demonstrated, however, that replicability means doing more than just repeating projects at a larger scale. It will require addressing constraints in housing markets, institutional capacity and finance, and improving urban management. In 1972, given the lack of solutions to urban problems, coupling learning with doing appeared sensible as the Bank entered a new sector of lending. In 1982, based on a decade of experience, that strategy is shown to have been sensible, but will now have to be supplemented by applied research and development to provide analysis and approaches for future lending.

I. INTRODUCTION

1.01 The purpose of this paper is to review the evolution and performance of urban operations in relation to the objectives established in 1972 and elaborated during the 1970's. 1/ The initiative to undertake this retrospective review comes upon the completion in June 1981 of the regionalization of urban operations and the transformation of the Urban Projects Department into the Urban Development Department, a Sector Department in the Operations Policy Staff. Over the past decade, the number of professional staff working full time on urban projects has grown from 10 to 83 as lending activities have expanded from a single project in FY72 to more than 90 projects under consideration and preparation for the FY82-86 lending program. Urban operations are now integrated into the regional structure of the Bank.

1.02 It is expected that the regionalization process will sharpen the regional perspective of urban lending and improve the projects' fit into country and regional priorities. This process involves adapting the sectoral perspective on urban project experience to the regional context. An essential step, therefore, is establishing this sectoral perspective. What have been the objectives of Bank urban lending? How have they been operationalized over time? What has been the performance of urban projects? How have initial lessons been incorporated into subsequent operations? The purpose of this review, therefore, is to assist the regional urban projects divisions to look forward in defining appropriate regional strategies for urban lending. The story presented below is not and cannot be definitive; data in many cases are limited and, more importantly, only a few of the 62 projects undertaken have been "completed". Even in those, households are still adding to their houses and improving their neighborhoods. Evaluating the impact of urban lending is therefore at best of an interim nature. Nor does the review presume to be comprehensive in its presentation of urban project experience; it is necessarily selective. It is hoped that this initial effort to assemble the relevant facts and to interpret them will encourage further evaluation.

1.03 The paper reviews the experience of urban lending in the context of the objectives established in 1972. Part II presents those objectives as formulated and elaborated during the 1970's. The paper then examines the various lending strategies and project types. Part IV reviews the implementation experience of urban projects, focusing on major issues affecting program replicability. This experience in the field is complemented by a discussion of the management of urban operations within the Bank. Part VI examines six types of impact of urban lending. The paper concludes by identifying the trends for future lending and the major issues to be addressed in the next few years.

1/ Urban operations refer to Bank-assisted projects processed by the Urban Projects Department and not to other Bank-assisted projects located in urban areas.

II. THE SETTING OF OBJECTIVES

A. The Challenge of Urban Growth

2.01 The increasing importance of urbanization in the developing countries was recognized at the beginning of the 1970's. Projections of past trends suggested that massive urban growth was likely to continue into the future, with the likelihood that by the year 2000, more than half of the world's population would live in urban areas. In absolute terms, urban population was expected to grow from 1.3 billion to 3.3 billion persons, an increase equivalent to the world's population in 1965. Even the least urbanized region of the world, Africa, expected its urban population to quadruple between 1980 and 2000. Countries which had been largely rural were being transformed within two generations.

2.02 The demographic view of urban growth provided only a partial perspective. A substantial share of the gross domestic product in most of the Bank's member countries is generated in urban areas. Cities and towns have been the sites of large-scale capital investment and have offered job opportunities and higher incomes to rural-urban migrants. As cities have grown, they have become increasingly important centers of industry, commerce, and trade. High productivity in urban economic activity has been an important part of national development, providing many of the goods and services required for development of other sectors.

2.03 The economic and physical growth of cities has also brought increasing demand for essential services, such as shelter, water supply, sanitation, transportation, and communications. Without the provision of these services, congestion, insecurity, and poor sanitation substantially raise the cost of urban residence and employment. As costs increase, productivity declines or at best grows at a slower rate. High productivity, therefore, depends on coherent policy and efficient investment in urban services if it is to be maintained over time. Unfortunately, the need for sound policy and strategic investments was not fully appreciated in the 1960's in most countries. Governments frequently mounted expensive public housing schemes, extended water supply networks, and built roads on an *ad hoc* basis, without a long-term view of how they fit together in relation to anticipated needs. Policymakers and technicians lacked adequate technical and financial solutions to the problems they anticipated.

2.04 By 1970, the urban dilemma appeared particularly intractable because awareness of urban needs had developed at the same time as an international consensus was emerging that the rural sector should be the priority for assistance. Urban investment which used scarce public funds would divert needed resources from the rural sector. This view was supported by the fact that urban investment was frequently subsidized at the time and benefited only a minority of the population. Moreover, urban services with high unit costs, provided on a subsidized basis, could not be extended to the urban masses. It was therefore essential that a new approach be found which acknowledged that the urban sector could and should pay for itself and which provided services which were affordable to the urban poor and thus permitted replicability for the sector as a whole.

B. The Bank's Objectives in the Urban Sector

2.05 Within this context, the Bank identified its primary objective in the urban sector in broad terms: To assist member governments to develop approaches for the provision of urban services and employment in an efficient and equitable manner. At a general level, this objective implied the need:

(a) to develop new policies and approaches in the management of the urban sector and specifically the provision of services;

(b) to address solutions to the urban poor who constituted the majority of the urban population in most developing countries;

(c) to develop "urban" approaches which linked shelter, infrastructure, transport, employment, and social services, thereby improving the efficiency of urban investment on a city-wide basis;

(d) to reduce the financial burden for urban development on the public sector and to shift it towards the private sector and the urban population itself.

These requirements in fact became concrete secondary objectives for the short and medium term. They included the following:

(a) to demonstrate low-cost technical solutions for shelter, infrastructure, and transport which were affordable to the urban population and could be progressively improved over time;

(b) to demonstrate that it was possible to provide services for the urban poor on a non-subsidized basis;

(c) to demonstrate the feasibility of comprehensive "urban" planning and investment programming procedures suitable for rapidly changing urban conditions;

(d) to demonstrate the replicability of the above solutions.

2.06 These objectives were presented by Bank management to the Board of Executive Directors on May 23, 1972 in the form of the Urbanization Sector Working Paper. The paper identified the scale and nature of the problems posed by the urban sector in the Bank's member countries. It noted that many Bank Group activities in the water supply, transport, education, and industry sectors were already located in urban areas and were thus contributing to urban development. However, these sectoral efforts were not integrated into a framework which took advantage of the many complementarities between shelter, infrastructure, employment, transport, and location. Recognizing the dimensions and complexity of urban problems and the false starts that had been tried by other aid agencies in the 1950's and 1960's, the paper cautioned against ambitious and "quick fix" solutions. Rather it counseled selectivity in the types of projects undertaken and an approach of "learning by doing" and then expanding as the Bank gained experience and refined its approach over time. Through this strategy the Bank Group would not "solve" these problems but rather should "exert a catalytic or dynamic influence on the pattern of growth through the project itself, or through the linkages with other sectors and the overall planning involved".1/ It was recognized at the outset that initial individual projects would achieve only limited results. Over time, projects would address the multiple policy and institutional issues in a programmatic manner and eventually have a sector-wide impact.

2.07 This strategy was intended to be deliberately experimental. Projects staff would explore different technical solutions with Borrower agencies in order to identify solutions appropriate for individual countries and cities. This research and development stage would be difficult, given the lack of Bank experience in the urban sector, and would necessarily involve high staff coefficients as both the Bank and its Borrowers gained experience in preparing, appraising, supervising, and implementing projects. The urban lending program would be closely monitored and early projects would be evaluated during implementation in order to determine the applicability of project approaches to similar situations in other countries. This decision led to the launching of a parallel urban research program within the Urban and Regional Economics Division of the Development Economics Department. This division initiated in-depth evaluation studies of early projects in Senegal, El Salvador, Zambia, and the Philippines in a collaborative effort with the International Development Research Center of Canada, whose findings have been reported to management and the Board.2/ It also began longer-term research on project-related subjects such as housing, land, municipal finance, and national spatial strategy.

1/ Urbanization Sector Working Paper, June 1972, p. 57.

2/ See SecM81-612 of July 13, 1981, Urban Shelter Projects: Report on IBRD/IDRC Special Evaluation Program.

2.08 In financial terms, the urban lending strategy was not primarily intended to transfer Bank resources as much as it was intended to provide technical assistance to establish a framework for investment from other sources. The financial requirements of the sector were, in any case, far too large to be met by the Bank alone, or indeed, external assistance as a whole. A new program of urban lending reflecting these concerns was proposed for the years FY72-76, comprising a total of 38 operations. Two-thirds were to be "sites and services" projects reflecting the perceived need to provide low-cost, affordable shelter and infrastructure to low-income urban residents through the mobilization of private savings and self-help construction. The remaining projects included urban-regional development schemes, urban transport, and other intra-urban investments. These efforts were seen as points of entry into the urban scene. At the same time the paper was quite explicit that individual projects were to be designed to improve the "efficiency of the urban centers both for production and living". 1/ The adoption of the paper by the Board of Executive Directors was closely followed by approval of the first urban lending operation, a sites and services project in Senegal in June 1972.

C. The Elaboration of the Bank's Objectives

1. The Housing Sector Policy Paper, May 1975

2.09 By early 1974, several major policy issues had been raised during the preparation of the initial urban projects. 2/ These included the extent to which the Bank Group should finance the construction of completed shelter units or cores, the income levels of beneficiaries of Bank-assisted projects, and the relation of shelter or housing projects to other investment programs in individual cities. The Bank approach proposed in the 1972 paper had been supported by an Urban Panel which had convened in October 1974. However, additional issues had been raised in the field which suggested broadening of the approach. The panel had concluded that upgrading existing settlements was of equal priority as new sites and services development, in part because of the advantages in physical access settlements provided to the poor. Access was considered important in terms of its linkage of shelter, employment, and services and the efficiency of the city. In this context the issue of urban transport was also raised. In short it was being emphasized that efficient project design should take into account the complementarity of urban services and that the Bank should improve its projects accordingly.

1/ Urbanization Sector Working Paper, June 1972, p. 55.

2/ Senegal in West Africa; Botswana, Zambia, Kenya, Tanzania in East Africa; Jamaica, El Salvador and Nicaragua in Latin America; India (Calcutta), Indonesia and Tunisia.

2.10 These discussions as well as two years of initial contacts with governments led to what eventually became "conditions" for urban lending as elaborated in the Housing Sector Policy Paper, May 1975. These conditions included the following:

(a) The government had to have a commitment to help the urban poor.

(b) The government should accept the granting of land tenure to project beneficiaries, either in slum improvement or sites and services projects.

(c) The government should agree to reduce housing and land market imperfections through the improvement of pricing policies and the reduction of subsidies, as reflected in cost recovery policies for urban shelter and infrastructure.

(d) The government should agree that projects should fit within a broader integrated approach to urban planning and investment.

Agreement on these subjects usually was translated into project design, although in many cases the "conditions" turned out to be target objectives which were pursued during project implementation and discussions about subsequent lending operations.

2.11 Operationally, the paper recommended that the Bank Group should be able to finance the construction of completed houses or core units on a selective basis depending on the conditions found within individual cities. This recommendation was based on research on urban housing markets in developing countries and the conclusion that housing and infrastructure standards for individual projects should be linked to the income levels of intended beneficiaries and specific countries conditions. 1/ The methodology for this approach had been elaborated in 1974 in the sites and services paper prepared by Bank staff. The approach represented a major step forward in the state of the art of urban project design. This country-, city-, and neighborhood-specific approach contrasted with the previous practices which sought to establish prescribed norms on a global basis, for example, the minimum space per person or number of rooms per dwelling unit. The approach thus represented an important shift with which many borrowers did not initially agree. Education, demonstration, and dissemination therefore became important.

2. Urban Transport Sector Policy Paper, May 1975

2.12 The Bank had received urban transport project proposals in 1972-74 from member countries which frequently involved heavy capital and recurrent

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1/ See Orville Grimes, Jr., Housing for Low-Income Urban Families, The World Bank, 1976.

expenditures, while appearing unrelated to the immediate needs of the largely low-income urban population. These included proposals for a metro in Caracas and a beltway around Sao Paulo. In order to articulate an approach to urban transport consistent with the Bank's broader sectoral and city-level objectives, the Urban Transport Sector Policy Paper, noted that: "Fundamental to the Bank's approach is the need to place the physical elements of urban transport projects in the context of policy measures, institutional development, and management solutions." 1/ Importantly, the paper stressed that "primary emphasis will ... be placed on low-cost public transport providing greater access to job opportunities, and on facilities for commercial traffic, cyclists, and pedestrians." 2/ The rationale for urban transport lending was clearly stated: "Urban transport is in many respects a leading influence in determining urban patterns both physical and social; as such, projects and policies in this field lead directly into general policies and plans for improving urban structure and productivity, and reducing urban poverty." 3/ The paper noted candidly that the Bank had few staff experienced in the sector and consequently could only begin lending operations on a highly selective basis, with operations "chosen for their potential demonstration impact and widening of experience ... and concentrated in cities where the authorities demonstrate willingness to consider and implement bold measures progressively to adapt their policies to the mounting pressures of rapid urban growth." 4/ The paper concluded with a proposed lending program for FY75-79 of two projects per year, possibly increasing to three per year at the end of the period. This also reflected the deliberate decision to concentrate more on shelter than on urban transport during the first few years of urban lending.

3. The President's Speech to the 1975 Annual Meeting

2.13 As the Bank's understanding of development issues and the poverty associated with them increased, the urban dimensions of poverty had become better appreciated. Staff work during 1974-75 led to the publication of The Task Ahead for Cities in Developing Countries 5/ in 1975 and the decision to make urban poverty the major theme of the President's Speech to the Annual Meeting. Throughout 1975 there was considerable debate over the objectives of Bank intervention in urban areas. Added to the agreed objective of improving urban services for low-income population there emerged strong interest in the need to generate employment for the growing urban population. A major recommendation of the 1975 speech was that, given the expected increases in urban population, renewed efforts should be devoted to promoting employment opportunities. These programs should include the use of credit, training,organization,

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1/ Urban Transport Sector Policy Paper, May 1975, p. 13.

2/ Ibid., p. 14.

3/ Ibid., p. 58.

4/ Ibid., p. 59.

5/ Beier, Churchill, Cohen and Renaud, The Task Ahead for Cities in Developing Countries, World Bank Staff Working Paper No. 209, 1975.

marketing, and other forms of assistance to encourage the creation of small enterprises many of which had been included in early projects. The cost of job creation should be kept low in order to provide the largest number of jobs with the limited capital available. This well intentioned objective has remained elusive to this day (see pages 20-21.

2.14 The President's statement that the Bank was prepared to assist member governments to face urban problems led to a large number of requests for Bank assistance. At the project level, individual efforts were now to include shelter, infrastructure, related social services, and employment components. As such, projects became integrated urban investment programs, requiring the participation of institutions from many sectors and a high degree of inter-sectoral coordination. Their target was to be the urban poor, identified according to the income levels and living conditions found in individual cities.

2.15 In addition to the impetus given to urban sector lending, the 1975 speech also led to the decision that other Bank activities affecting urban areas should be monitored within a Bank-wide Urban Poverty Program (UPP). This program would have two objectives: to monitor Bank progress in directing the benefits of urban-related lending towards the urban poor and to provide support to operational activities with an urban poverty focus. A Unit within the Urban Projects Department, the Operations Review and Support Unit (URBOR) was established in 1975 with this function. Its major activities involved "outreach" in providing assistance to other sectors such as industrial development and finance and water supply and sanitation. In the latter some six man-years of support were provided during FY78-80, affecting some 38 projects in the sector. This resulted in an increase in the share of poverty lending in water supply projects from 14 to 18% over the three years, a jump from US$52 to US$145 million in benefits to the urban poor. At the same time, the design of projects in other sectors was monitored to evaluate the estimated benefits of Bank lending directed toward the urban poor. This work was placed under the guidance of the Urban Poverty Task Force which provided regular progress reports and technical papers to senior management. Although the work of the Task Force and URBOR was often accompanied by controversy, it is generally agreed that it created an environment in which consciousness was raised about the significance of urban poverty and the opportunities which Bank activities offered to alleviate it.

4. Basic Needs in Shelter, September 1980

2.16 By 1980, many of the policy objectives contained in the above documents were being seen within the framework of "basic needs" even though the Bank's approach stressed improving the efficiency of provision of urban services. The orientation towards basic levels of shelter, infrastructure, and health had been reflected in all of the projects under implementation. The Shelter paper, prepared as part of the Poverty and Basic Needs series in September 1980, addressed the scale of the shelter problems in developing countries and made the argument that the only available solution to the problem was the reduction of standards to affordable levels to permit cost recovery and replicability. Replicability of urban shelter and infrastructure programs on the scale required for any individual country would continue to exceed the resources available in that country unless the shelter programs were undertaken at standards affordable to the beneficiary population. Only in this way could self-regenerating large-scale programs be launched. The preconditions to financial replicability were appropriate standards and sound pricing policies, while the precondition for physical implementation, cost recovery, and maintenance was the strengthening of housing and infrastructure institutions in the urban sector. These points represented a more informed restatement of the Bank's initial objectives as established in 1972.

D. Summary

2.17 The process of formulating and elaborating Bank objectives in the urban sector involved considerable debate and controversy during the 1970's. While some consensus existed that the Bank should address "urban" sectoral issues, and not restrict itself to sub-sectoral areas such as housing or transport, extensive discussions occurred over whether projects and policy dialogue should be focused on "urban development" or "urban poverty", whether sub-sectoral projects provided reasonable points of entry into larger debates over sectoral policy, or whether integrated projects could be expected to generate employment while also improving infrastructure. Interest in urban employment generation resulted in lengthy discussions between departments within the Bank over the best approach to employment questions, including the efficacy of targetted project components versus broader city-wide employment programs. In some cases, it was felt that national policies and economic factors were likely to be more important in employment generation than individual city-level interventions.

2.18 The process of elaborating the Bank's objectives in the urban sector also demonstrated the diversity of conditions which urban sector lending would have to address. Individual and country perspectives on the issues mentioned above varied tremendously from region to region, reflecting the extent of urbanization, urban poverty, and government policies found there. These conditions suggested that some cities might be appropriate for broad, integrated city-wide approaches, while others could not effectively handle large-scale investment. It was apparent that "urban" policy objectives would have to be achieved through the use of different strategies over varying time periods, according to local conditions. Ientifying operational targets for those strategies would be the next step.

III. LENDING STRATEGIES AND PROJECT DESIGN

3.01 The development of an urban lending program was influenced by many factors. While the Board had approved the objectives of urban lending, the formulation of lending strategies and the choice of project instruments were left to urban projects staff. Requests from potential Borrowers varied tremendously, with India seeking major assistance for Calcutta, while less urbanized countries such as Botswana requested support for solutions to problems in small towns like Gaberone and Francistown. The wide variation in Borrower requests reflected the great differences in urban conditions, the size of population, the level of development, and technical sophistication. Some governments were well aware of "urban" problems, while others viewed the spread of squatter settlements as a "housing" problem. The range of perceptions of urban transport also varied, with some officials believing that constructing expressways or purchasing new buses would ease the demand for transport and congestion, while others sought to make better use of existing road space and traffic facilities. In all cases, officials felt their capital cities were too large, whether it was Bamako, Mexico City, or Seoul, and that migration had to be stopped.

3.02 The combination of "stylized facts" about the urban sector which were prevalent in many countries and the shared problems of shelter, infrastructure, transport, and institutional weakness suggested that the major thrust of Bank lending strategies in the urban sector should be to orient the thinking of local officials towards "urban" solutions rather than simply individual sub-sectoral approaches. It was clear, however, that such an urban view could only be achieved over time. Lending operations would have to address the major issues and problems perceived by government and only through a gradual evolution could the Bank and the government develop a clearer understanding of "urban" in specific circumstances.

3.03 Part III of this paper will present the evolution of the urban lending program in terms of the different lending strategies and project types which were developed in response to various country situations. Four major project types will be reviewed: shelter, urban transport, integrated urban projects, and regional development. Table I presents the distribution of project types over time.

TABLE I: URBAN PROJECT TYPES

Fiscal Year	Shelter	Urban Transport	Integrated Urban	Regional	Total
72	2	-	-	-	2
73	1	1	-	-	2
74	2	2	1	-	5
75	5	-	-	1	6
76	2	1	-	-	3
77	2	1	2	-	5
78	7	2	4	-	13
79	3	1	4	-	8
80	7	1	1	1	10
81	5	1	1	1	8
TOTAL	36	10	13	3	62

3.04 Table I also illustrates the continuing emphasis on shelter and infrastructure projects. There has been a continuing demand for projects within these subsectors. In FY77-79, there was an increase in the number of so-called "integrated urban" projects, which in practice meant either city-wide investment programs or multi-sectoral projects usually including transport and business support components. While many shelter projects included business support, the integrated urban projects financed these components as well as urban transport on a larger, more ambitious scale. Some ten projects of this type were approved during FY77-79, reflecting increasing emphasis on addressing urban poverty through a multi-sectoral program within individual cities. Urban transport projects have remained small in number, although Borrower's requests have begun to increase as initial projects have proven successful. Regional development has been largely focused on Korea, where two projects are under implementation.

3.05 Table II presents the regional breakdown of urban lending by fiscal year.

TABLE II: REGIONAL BREAKDOWN OF URBAN LENDING

Fiscal Year	East Africa	West Africa	EMENA	LAC	South Asia	East Asia
72	-	1	1	-	-	-
73	-	-	-	1	-	1
74	1	-	2	1	1	-
75	3	-	-	1	-	2
76	-	-	-	1	-	2
77	-	1	-	1	2	1
78	3	1	2	5	1	1
79	-	1	1	3	-	3
80	2	1	-	3	1	3
81	1	-	2	2	1	2
TOTAL	10	5	8	18	6	15

3.06 The size of the lending program has varied across the regions, reflecting to some degree the scale of urbanization and institutional capacity, with the LAC and East Asian regions having the largest number of projects, accounting for over half the urban lending program. While the size of the regional urban programs is significant, the timing of projects through the decade of lending is also informative. Despite being the most urban region, the countries of the LAC region such as Brazil and Colombia were not initially receptive to the low-cost, nonsubsidized urban projects which the Bank was prepared to finance. In contrast, countries where Bank assistance was actively sought, as in Botswana, rather quickly accepted the Bank approach. Changing governmental attitudes towards the urban poor and more effective staff communication with LAC governments led to a rapid expansion of projects during FY77-79 with nine projects in three years, including three in Brazil and two in Colombia. The consolidation of the East Asian program in the last three years reflects successful early experiences in Indonesia (III and IV projects), Philippines (II and III), and Korea (II and III).

3.07 The regional lending patterns also reflect major differences in project types, as shown in Table 3.

TABLE III: Regional Distribution of Project Types

	Number of Projects					
	E. Africa	W. Africa	EMENA	LAC	S.Asia	E. Asia
Shelter	10	3	3	10	-	10
Transport	-	-	2	3	2	3
Integrated Projects	-	3	3	4	4	-
Regional Development	-	-	-	1	-	2
TOTAL	10	6	8	18	6	15

3.08 All regions except South Asia have experimented with freestanding shelter projects in an attempt to address the critical needs of the urban population. While East Africa has concentrated on the shelter projects, the other regions have widened their scope by experimenting, to some degree, with the other project types. South Asia projects have included shelter components within integrated urban projects from the outset, since FY73, reflecting the multiple needs of the large Indian cities.

A. Urban Shelter Projects

3.09 As noted above, the first urban shelter projects financed by the World Bank reflected a policy approach which differed significantly from what most governments and practically all development assistance institutions were doing at the time. They were self-consciously not "housing projects", but were rather "urban shelter projects", and their design assumptions included the following:

(a) The financial burden for urban investment should not be borne by the public sector, but in large measure by the beneficiaries themselves.

(b) Public sector interventions should be limited to services which people could not provide for themselves, such as city-wide planning and construction of infrastructure, with households doing the rest.

(c) Programs to provide urban services should focus on income groups without access to existing public programs.

(d) Project level investments should encourage the mobilization of private savings and self-help efforts.

(e) Design standards for shelter and infrastructure should depend on the income group to be served, according to the city and location, and should be affordable by them.

(f) Projects based on the above assumptions could, over time, be expanded into replicable large-scale national programs.

While these principles may not appear controversial in 1981, they represented a radical departure from policy in most developing countries, where the urban middle class benefited from subsidized pricing of services, particularly housing, while the majority of the population lived in unserviced slums and squatter settlements. As a basis for discussion with Borrowers, they proved to be very strategic points of entry into the urban scene, because most governments could afford neither the financial costs of conventional housing solutions nor the political costs of bulldozing existing squatter settlements. They had to examine other alternatives.

3.10 Shelter projects addressed two fundamental problems: the need for new shelter units and the need to improve existing substandard units, whether as slums or unserviced squatter areas. The first problem was addressed through the sites and services concept which involved the provision of serviced land, including roads, water supply, sanitation, drainage, electricity, construction loans for housing, and social services. The sites and services approach was intended to be flexible and did not imply preconceived notions about architecture, costs, or building materials. 1/ Early projects in Senegal, Botswana, Jamaica, Tanzania, El Salvador, Kenya, and Peru were largely focused on sites and services. The second problem was addressed through the concept of slum upgrading, which assumed that households would be permitted to stay in their existing settlements and that, with only minimal demolition and relocation, infrastructure networks including water supply, sanitation, roads, footpaths, drainage, and electricity would be extended into the settlements. Projects in Indonesia, Zambia, India (Calcutta and Madras), 2/ Upper Volta, and Colombia were focused on upgrading, and assumed that the present needs of the urban population were of equal, if not higher, priority than those requiring new units. Both approaches required that households would receive security of land tenure, thereby providing an incentive for the mobilization of savings and self-help efforts. In both cases, households would pay for infrastructure provided by public sector agencies and finance their own housing. Designs of individual projects would depend on the income levels of the households themselves.

3.11 During project preparation these concepts led to heated debates, initially over "standards", with most governments at both the political and technical levels arguing that reduced standards were unacceptable. This subject was often followed by disagreements over the recovery of investment costs, particularly in the case of water supply and other infrastructure services where colonial traditions and political imperatives resulted in the free distribution of water to the urban population. The sites and services approach, combining these assumptions, went even further, challenging building codes and suggesting that households should be able to build houses according to their own preferences, including design, materials, schedule, and degree of finish.

1/ The initial application of the concept even by Bank staff, however, tended to be rather rigid. Greater flexibility resulted from implementation experience.

2/ Both projects included shelter components of this type.

3.12 Despite substantial resistance in some countries, with officials often complaining that recommended standards were "not good enough for our people", the initial and in some cases pilot projects demonstrated that both sites and services and slum upgrading represented viable alternatives to the continued growth of uncontrolled, unserviced settlements. Once governments were convinced of the approach, as in the Philippines, Indonesia, Kenya, India and Nigeria, repeater projects were designed either to increase scale of programs in the same city or to extend the concepts into other urban areas. Pilot projects demonstrated that it was possible to dramatically reduce costs in shelter provision and infrastructure and provide affordable solutions. These solutions were targeted largely to the urban poor, also demonstrating that it was possible to improve their living conditions as well. By 1981, projects were reaching to about the 20th percentile in the urban income distribution, while upgrading projects reached lower. These impacts are described in greater detail in Part VI of this paper.

3.13 In quantitative terms, from FY72-81 some 36 urban shelter projects were approved by the Board, with the average total project costs of US$53.2 million of which 37% was foreign exchange. The average Bank loan/credit amount for the shelter projects is US$24.9 million. Shelter projects have on average devoted 65% of total project costs to their primary components, either sites and services and/or upgrading. They have benefited some 25,000 households per project. Over time, these figures have increased as the average total project cost has increased from US$29.0 million during FY72-76 to US$65.3 million in FY77-81, loan/credit amounts have increased to US$30.4 million and the number of households provided with services has grown to an average of 62,000 by FY81. The evolution reflects increasing confidence with the feasibility of preparing and implementing these projects. Although there have been problems of varying severity in implementation, the projects have had substantial success in physical terms, reducing plot sizes, unit costs for infrastructure, and in shifting government agencies towards more cost-effective approaches in the shelter sector (See Parts IV and VI).

3.14 Enduring success with this project type ultimately depends on a simultaneous improvement of institutions working in the sector. The scale of subsequent projects, even after policy differences and implementation bugs have been resolved, will be determined by the ability of agencies to staff their operations, to plan and budget effectively, and to carry out their responsibilities during implementation. Institutional development, therefore, is the major next step in further developing urban shelter projects and indeed is the precondition for national replicability.

B. Urban Transport Projects

3.15 The second project type or instrument for urban lending was urban transport. As noted above, early policy documents had identified the importance of urban transport within the management of specific cities and the sector as a whole. Many cities were devoting sizable amounts of capital to major road improvements, rail systems, and bus purchase in order to meet growing needs, yet few governments had a coherent view of sector as a whole, particularly the long-term financial implications of these investments.

3.16 Lending for urban transport started relatively slowly in 1972-73, with projects in Malaysia, Iran, and Tunisia, and transport components in integrated urban projects in Turkey, and India (Calcutta). Each of these projects represented different approaches to transport problems, with some 91% of the Malaysia project costs allocated to road construction, half of the Iran project devoted to bus purchase and another 20% for traffic management, while the Tunisia project combined various transport improvements, including bus purchase, within broader support for the newly created District of Tunis. Transport sub-projects in the initial Calcutta project were almost exclusively focused on road construction and improvements, while the Istanbul project financed technical assistance for transport planning. The diversity of this approach reflected the experimentation and learning envisaged in the Urbanization Sector Working Paper. After these initial efforts, there was a pause during 1974-75, when a number of projects and components were under preparation, but no operations were approved. During this period there was extensive discussion about the direction of Bank lending in the sub-sector, culminating in the approval of the Urban Transport Policy Paper in May 1975. As noted in Part II, this paper established a framework for lending, which gained some momentum thereafter. It is interesting to note that at this time, Bank urban staff were taking strong positions against construction of major roads and rail systems in cities in developing countries, recommending that transport investments should focus on improving use of existing facilities and services for the urban poor. This policy approach, however, proved to be difficult to achieve in many cities as their physical expansion frequently required transport investments of all types. This is reflected in the general trends in transport lending which are presented below. These suggest that, unlike the shelter projects, lending did not focus on a prototypical transport project, but reflected much greater variation according to city conditions.

3.17 From 1972 to 1981, some 11 urban transport projects were approved by the Board, while another 11 urban projects included significant transport components. The total costs of the 11 transport projects amounted to some US$1254.5 million, of which the Bank Group financed US$546.9 million. In addition, the transport components of urban projects cost some US$275.1 million of which the Bank Group financed US$139.5 million. Taken together, urban transport lending in these two forms amounted to some US$686.4 million. The range of project size varied from US$159 million for the second Brazil Urban Transport Project in Porto Allegre to US$0.3 million for components in the second Urban Development Project in Kenya.

3.18 Within urban transport-related projects, the following breakdown of sub-component costs indicates the investment focus of projects:

TABLE IV: DISTRIBUTION OF URBAN TRANSPORT INVESTMENT AS PERCENTAGE OF TOTAL PROJECT COSTS

Road construction, improvement, maintenance	32.0%
Rail systems 1/	24.0%
Bus acquistion, facilities, priorities	22.0%
Traffic management	9.0%
Training and technical assistance	6.0%
Other (sector lending)	6.0%
Pedestrian facilites	1.0%
	100.0%

1/ Only one suburban railway project in Porto Alegre, Brazil.

3.19 These figures indicate that 56% of urban transport investments went to improvements in transport infrastructure (road and rail) which was not the primary thrust of the 1975 policy paper. It is important to add that much of the road infrastructure investments were designed to benefit inter alia public transport vehicles and low-income areas. The low proportion of component costs devoted to traffic management reflects the low cost/high impact nature of such measures. The following breakdown of the frequency of sub-components reveals, perhaps more appropriately, the balance of attention given to traffic management and bus measures.

TABLE V: DISTRIBUTION OF URBAN TRANSPORT COMPONENTS

Road construction, improvement, maintenance	27%
Bus acquisition, facilities, priorites	25%
Technical assistance and training	22%
Traffic management	16%
Pedestrian facilites	6%
Rail systems	3%
Other (sector lending)	2

This table illustrates that some 38% of the components (traffic management and technical assistance) address issues of policy and better use of existing facilities.

3.20 An important part of transport lending has been the attention devoted to management questions, as suggested above. A significant number of projects have involved traffic control measures, improved financial management of bus companies, more efficient programming of road investments, and attention to the recurrent budget implications of transport investments. A conclusion from this experience has been that, while the institutions responsible for urban transport are relatively well developed in some countries, they generally require strengthening in managing the sector and its variety of sub-component parts. Where strong federal urban transport institutions exist, with well developed policies and financial mechanisms as in Brazil, it has been possible to develop large urban transport lending programs rapidly (three projects in four years) amounting to US$339 million in lending.

3.21 Given the diversity of transport approaches, there is a need to review Bank experiences in the urban transport sector and to update the sector policy paper in the light of these experiences, as well as to identify present and future issues in the sector. Those issues would include regional strategies, energy issues, rail systems and maintenance, and reassessing road pricing which has proved politically unacceptable despite efforts to introduce it following the Singapore experience.

C. Integrated Urban Projects

3.22 The third project type was the so-called integrated urban project. These projects consisted of a range of sub-sectoral components, including various combinations of shelter, infrastructure, transport, solid waste management, business support, health, nutrition, and education. They were intended to provide broad improvements throughout the city, even if individual components were not launched on a city-wide basis. The rationale for city-wide approaches had been developed in urban studies at the end of the 1960's which argued that complementary urban investments were likely to have a greater impact on urban development than more narrow sub-sectoral efforts. Cities which had identified priorities across sectors through comprehensive planning could serve as experimental sites for city-wide lending. The case of Calcutta was the first Bank effort of this type, in response to deteriorating conditions in the city and the urgent request of the Government of India at the time. The project consisted of components which were "treated as elements of an urban investment program rather than as self-contained sub-projects." 1/ The project included finance for some 44 of 160 sub-projects over six sectors within the investment program of the Calcutta Metropolitan Development Authority (CMDA). In addition to its intended benefits for the city population, the project sought to strengthen the capacity of CMDA to plan, finance, execute, and supervise projects. It was intended as the first in a series of Bank projects, and set the stage for a second and a third IDA credit, the latter now under preparation.

3.23 While the Calcutta project involved direct financing and has had concrete achievements, two other efforts were initiated with less positive outcomes: the Istanbul Urban Development Project and the Bogota Urban Planning exercise. In Istanbul, the Bank financed a city-wide planning exercise which included preparation of a master plan for the city, a detailed urban transport model, and several pilot projects to be identified during the planning effort. While this exercise produced a master plan and to some extent improved the understanding of the long-term needs of the city, the Istanbul experience demonstrated to many Bank staff that comprehensive master planning was a slow process which could not keep up with the rapid changes in most cities. Emphasis on physical issues often diverted attention away from the more important institutional and financial problems whose solutions would ultimately determine the extent of physical investments. Simultaneously, the Bank's experience as executing agency for the Bogota urban study produced the same conclusion and added to growing skepticism about conventional master planning approaches. This perspective was also extended to sophisticated urban economic models which had been developed during the 1960's. A Bank review of these models concluded that they did not have much relevance for developing countries.2/

3.24 In place of these approaches, Bank staff increasingly focused on the need to program complementary investments in shelter, infrastructure, transport, business support, and social services in a strategic basis over specific periods. This approach included: i) relating resource availability to the scale of planned investments; ii) emphasis on short- and medium-term priorities consistent with several long-term options rather than aiming for an optimum long-term plan; and iii) attention to complementarities and other interrelationships among different types of investment. Developing this approach took some time, but resulted in a group of integrated urban

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1/ Appraisal Report for the Calcutta Urban Development Project, Credit 427-IN, 1973.

2/ Rakesh Mohan, Urban Economic and Planning Models: Assessing the Potential for Cities in Developing Counties, John Hopkins University Press, 1979.

projects which were financed starting in FY77. These projects were distinguished from urban shelter projects by the scale of individual components, the number of agencies involved within a city-wide framework, and an effort to "integrate" investments. They were presented to the Board as a "desirable, multi-faceted approach recognizing the many interrelationships within the urban system". 1/ They were designed from a broader conceptual perspective, attempting to achieve an "urban" view, rather than by moving in steps from sub-sectoral efforts towards that perspective. The development of this approach is still very much in process and as with the other project types, implementation experience across the regions has provided useful lessons to improve design of subsequent projects.

3.25 The increased number and scale of individual components and the inclusion of institutional support resulted in projects which were somewhat larger than the urban shelter projects. Average total project costs were US$84.0 million, with the average loan/credit amount of US$33.7 million. The foreign exchange component of total project costs was about 31%, somewhat less than the shelter projects. Their estimated rates of return were some 24%. 2/.

3.26 While many of the integrated projects are still under implementation and it is consequently difficult to evaluate their performance, they have nonetheless provided important insights into the project design process. The integrated projects could be considered the most "ambitious" of the project types in the sense that they sought to achieve an "urban" perspective through a single project, rather than moving through a series of operations towards that goal. They required extensive preparation and the participation of many agencies during implementation. Implementation problems have therefore been encountered. These projects have nevertheless had broad impacts, discussed in Part VI below, which justify the effort. The major lesson drawn to date from this experience is that while "integrated projects" should continue to have many sub-sectoral objectives, in some cases they can most efficiently address one or two sectors on a city-wide basis. 3/ In the case of Madras II, it was decided to emphasize the shelter and transport objectives, with other subcomponents having a less prominent role than in the first operation.

1/ Board discussion of the Madras Urban Development Project, SD-77-16, of March 28, 1977, p. 10.

2/ The methodology used for calculating the rates of return for these projects involved calculating the weighted average of rates of return for individual components, and did not take into account possible benefits from the complementarities. Even if higher rates of return were likely to result in such complementarities, no methodology exists to take these into account.

3/ Insights on this question are being provided by the City Study, a Bank-financed research project focused on Bogota, Colombia, which examined many of the interrelated parts of the urban economy.

D. Regional Development Projects

3.27 A fourth project type which has been launched only three times is the regional development project. As noted above, urban shelter projects have increasingly moved out of the capital cities in developing countries towards secondary urban centers. This trend has resulted in greater attention to the choice of regions as sites for urban investment, selection of criteria for specific cities and towns, and a broader concern for the growth prospects of the region. Multi-city projects represent 50% of the urban lending portfolio. These projects, however, rarely have had explicit regional development objectives. In contrast, three efforts, two in Korea and one in Mexico, have been explicit regional development projects, with components designed to have a broad, multi-sectoral impact on whole regions. The Korea projects have emphasized the urban and industrial aspects of regional development, while the Mexico project is more related to agriculture.

3.28 The first of these projects, the Secondary Cities Regional Project in Korea, approved in FY75, was located in the Gwangju Region, a relatively remote and lagging region of the country which had not benefited from national economic growth. The project included shelter and infrastructure in three towns, a fishery harbor complex in one town, a city market, access roads, and technical assistance to strengthen regional planning in the area as well as to support improvements in water supply. This project, costing some US$25 million, worked quite well and led to a second project in the same region, based on studies completed during the first. The second project included shelter, infrastructure, industrial estates, water supply and transportation, fisheries development and technical assistance, all on a larger scale, and cost some US$154.8 million in 1979. A third Korea project, focused on housing and land development, includes investment in the Gwangju region, among others. This experience has demonstrated the efficacy of complementary investments in related sectors and the rather substantial impact which can be achieved. As noted below, such efforts require extensive preparation and close coordination efforts, but this may be cost-effective, given the scale of impact in return. Potential implementation problems, howeverm can also be quite substantial.

3.29 A third regional development project, located in southeastern Mexico, was approved in 1981, and involves a multisectoral approach to the problems of some ten towns within the region. The project emphasizes its programmatic character, including shelter-related programs such as sites and services and upgrading, city-wide infrastructure, municipal facilities and services, productive activities including credit to artisans and small enterprises, industrial estates, training and promotional programs, and technical support and studies. This project costs US$468 million, and, while again requiring extensive preparation, is expected to have a very substantial impact in its region. Its financial cost is equivalent to ten urban shelter projects.

3.30 In each of the three regional projects, project design takes into account the need to strengthen the regional perspective within existing institutions, while also improving individual sectoral agencies. The programming of investments, followed by operations and maintenance, is complicated.

However, many of these activities would occur without the projects, although at lower levels of investment. The projects thus fit within an on-going regional context and seek to improve efficiency within areas which have longer-term economic potential. 1/ The choice of the regions reflects an economic evaluation of the regions and the decision to bring the regions into the economic growth process of their countries.

3.31 Considerable work needs to be done in refining the Bank's approach to regional development. The three projects mentioned above have raised many questions which remain to be answered, including the definition of objectives of a regional project, relationships between components, and criteria for evaluating their performance. Many efforts in other sectors, such as agriculture, industry, and transportation, all have major regional impacts. Urban lending needs to be more closely related to these sectoral activities as part of a comprehensive approach to regional development. It is hoped that the decentralization of urban shelter projects out of capital cities into secondary centers will encourage further development of approaches to regional investments by Bank staff and Borrower agencies.

E. Employment and Productivity in Project Design

3.32 One particular issue which has been raised during the formulation of the above project types and which deserves special attention is the generation of employment and productivity. Thirty-four of the 62 projects include measures intended to support small businesses as a means of improving employment opportunities in urban areas. Direct measures include: serviced land for business purposes, construction of markets and sheds, credit, technical assistance, training and studies. In addition, employment concerns have been incorporated in site selection, the integration of residential and commercial/industrial development, the inclusion of business plots for generating surpluses used in differential pricing, and in support of the construction industry. These efforts were experimental and reflected interest in urban employment at many levels in the Bank and in Borrower agencies. By 1982, there is a general consensus that the employment objectives have not been achieved, for both project-level reasons and more important conceptual issues.

3.33 At the project level, the relatively small size of business support components have not provided sufficient leverage to initiate the changes needed to assure success even at their modest level. The provision of credit illustrates this problem, because small amounts of credit within an urban project have not provided sufficient incentives for participating institutions to change their procedures to facilitate allocation and use of

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1/ On-going Bank research on the economics of employment location and regional development is expected to improve approaches to project design for regional investments.

credit by small entrepreneurs. Even if credit is provided, small components have not been able to go far enough to assure that the credit is put to efficient use, that goods and services are produced and marketed, and their financial return accounted for properly. Business support components which have sought to address all the steps in the process have become cumbersome and complicated, adding substantial organizational problems to the already limited institutional capacity found in cities. As project teams have become increasingly aware of these complexities, there has been a tendency to limit the size of these components, frequently restricting urban project interventions to the construction of markets and/or sites for small businesses, but more recently not including credit, training, and other forms of support. These latter components have become part of projects prepared by the Industrial Development and Finance divisions (IDF).

3.34 Despite early enthusiasm with the business support components, there has also been a growing understanding that urban employment should be considered within the broader objective of improving urban productivity. The forms of assistance mentioned above have largely been directed at improving the efficiency of the private sector and increasing its ability to provide income-generating opportunities. It has become apparent, however, that many of the constraints on private sector development and the productivity of individual cities result from the inefficiencies of the public sector. These inefficiencies include: technical inadequacies in the provision of services, economic inefficiencies associated with incorrect pricing policies, and quantative deficiencies in terms of the output of services provided. All of these increase the costs of economic activity within urban areas and reduce opportunities for employment and income-generation. As the Bank has gained increasing experience with individual cities, the need to reduce these public sector bottlenecks which constrain private sector development, as in Lagos or Cairo, has become an important objective of project design. Addressing these bottlenecks in some cities may be more important than providing direct support for the private sector. This strategic decision, however, must be based on prior analysis of local conditions and a judgment of the Bank's comparative advantage in particular cities.

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3.35 As indicated at the beginning of Part III, the choice of project type has depended upon the lending strategy adopted for specific countries. Those strategies in turn have developed on the basis of sectoral analysis, whether in the form of sector reports or detailed reconnaissance. Over time, project experience itself has become an important input into sectoral analysis and has influenced sectoral lending strategies. The importance of this process is reflected in the character of current urban sector work which initially attempted to provide a general perspective on sectoral policies and conditions. Recent work is focused on specific problem areas, such as housing finance in the Philippines, institutional capacity in Kenya, the role of municipalities in Ecuador, city-wide investment strategies in Lagos, Nigeria, or the choice of secondary centers in India or Peru. These studies will provide the rationale for future project design.

IV. IMPLEMENTATION EXPERIENCE

4.01 Part IV will review the major characteristics of the implementation experience of the urban lending program, relating this performance to the issue of replicability of projects. While the implementation experience of urban projects shares many of the features of other sectors, as documented by the Operations Evaluation Department, the most significant questions about urban projects concern their suitability as replicable models for financially and technically sound urban development. Implementation experience is an important criterion in this regard. However, given the relatively brief experience with only 14 of 62 projects fully disbursed, it is difficult to provide a definitive answer in quantitative terms. It is nonetheless possible to identify the major problem areas which have required special attention during supervision. These areas are discussed in the first section of Part IV and are subsequently complemented by presentation of standard quantitative indicators used by the Bank.

4.02 Before reviewing this experience, it is important to note that a a major factor influencing implementation of urban projects has been the flexibility of both the Bank and Borrowers in identifying and resolving problems in a new sector of lending. The strategy of research and development described earlier must necessarily be reflected in the process of implementation. Where both Borrowers and Bank staff have approached implementation with a flexible, problem-solving attitude, projects have progressed reasonably well. Where attitudes were more rigid, for a variety of institutional and political reasons, both in the countries and the Bank, implementation has proven to be more difficult.

A. Problem Areas and Replicability

4.03 The following aspects of implementation experience deserve special attention in relation to their implications for program replicability: institutional framework, land acquisition and tenure, cost recovery, backsliding on standards, project management, and experience with special components. In each case, these problems reflect difficulties that usually accompany "doing something new", but if left unresolved, would limit the ability of the executing agency to expand initial projects to larger scale programs. They are usually more severe in first projects but ease with implementation experience, suggesting the importance of looking at urban development from the long view. There are few quick fixes.

1. Institutional Framework

4.04 One of the early problems encountered during implementation has been the organization of project activities. As in other sectors, debates have occurred during preparation over whether projects should be executed by existing agencies or by new project units. In the urban sector this debate has been complicated by the existence of city-wide sectoral institutions having responsibility for a part of the activity included within the project.

In this context, project coordination becomes more than simply the scheduled phasing of complementary activities, but involves broader institutional questions of coordination and cooperation within cities. Given the novelty of the Bank's approach to urban shelter, infrastructure, and traffic management, projects have frequently been executed by special units which are expected to be reintegrated into existing institutions upon completion of first project activities. These new project units have frequently been difficult to start-up, with common problems of recruitment of staff and/or technical assistance, allocation of space, equipment, budgetary resources, and establishing procedures for communication and approval of project related decisions. New units have had difficulties obtaining approval for final engineering, land acquisition, coordinating with existing agencies in areas such as community development, construction and operation of infrastructure, household selection and occupancy on new sites, and traffic management.

4.05 Within the group of 62 projects, many variations have been adopted concerning organization of project activites. Projects in countries with weak implementation capacity tended to work through special units, as in Zambia with a project unit attached to the Lusaka City Council, or in Mali with a project unit attached to the Ministry of Public Works. In the Zambia case, the unit's staff and functions were reabsorbed into the City Council after completion. This process also occurred in Nairobi as the project unit for Dandora became part of the Housing Development Department. This approach has generally achieved better results compared to that using existing institutions as in the the Ivory Coast, where expectations proved to be optimistic. In countries with more experienced institutions, as in India or Indonesia, the executing agencies have incorporated project activities into their own programs and executed project components with relatively less of the "special treatment" which Bank-financed activities tend to receive. Most importantly, the organization of second projects reflects this approach suggesting that replicability is possible. As suggested below in Part VI on impact, strengthening urban institutions is one of the most difficult tasks of individual operations.

2. Land Acquisition and Tenure

4.06 A second common problem has been the acquisition of land for new development and the subsequent granting of secure tenure to project households. This problem has led to major delays in projects in all six regions, even with projects which are successful in other respects such as in Madras. Its frequency as well as fundamental importance in urban development led to research studies on land by Bank staff and consultants. 1/ In some cases, traditional customary law is in conflict with civil law prior to the initiation of a project, as in Upper Volta, making the acquisition of project sites a lengthy process and in some cases, an almost irresolvable problem. Urban projects have sought to reconcile competing land tenure systems, as in Ecuador, to introduce some legal order into a situation which defies collection of

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1/ See Harold B. Dunkerley et al, Urban Land Policy: Issues and Opportunities, two volumes, World Bank Staff Working Paper No. 283, May 1978.

property taxes and promotes inefficient settlement patterns. In some cases, as in Lesotho, projects have been used as vehicles for progressive policy change on land issues, with some success. In others, the financial interests involved in urban land markets have created political obstacles which delayed implementation. In order to overcome these problems, most urban projects now require advanced procurement of land, as in the second Madras project, and staff have devoted particular attention to the legal aspects of land transfers and tenure. In Liberia, the land issue proved to be the central factor in urban development and became the basis for the major component, land registration, in the proposed project. While land acquisition has been identified by OED as a persistent issue in implementation across sectors, its resolution is again critical in the urban sector if larger-scale replicability is to be achieved.

3. Cost Recovery

4.07 A third aspect of implementation which has proven to be difficult in some projects has been cost recovery. As noted above, reasonable cost recovery is an essential part of the Bank's approach in the sector. A paper on this subject was prepared by urban projects staff in 1980 for the Eastern Africa region after it was found that cost recovery for sites and services projects appeared low in relation to initial targets. The paper distinguished between cost recovery performance in sites and services projects and upgrading projects. For sites and services, the initial record on payments by beneficiaries was reasonably good, with a strong element of self-selection and pride associated with construction of new dwelling units. Problems developed, however, after the start-up period, as the necessary follow-up services such as maintenance and social services were not provided as promised. Households became disillusioned and increasingly reluctant to pay. This situation was reinforced by inadequate collection methods, the lack of sanctions for non-payment, and the absence of political will to enforce collections. Project experience thus confirmed that the capacity existed to pay the charges as developed during project design, but that diminishing willingness to pay together with ineffective collection systems became the cause of declining performance.

4.08 In contrast to sites and services, the paper noted that cost recovery faced many additional problems in upgrading schemes. By definition, the population already occupied the neighborhoods and houses selected for improvements. They did not always agree on either the need for upgrading or the obligation to pay for improvements. Even if the majority of households agreed to pay, the existence of a non-paying minority would create problems for the credibility and financial situation of the whole program. Problems such as collections and lack of sanctions were even more severe in existing neighborhoods which formed cohesive community blocs, thereby raising the political stakes. These problems have been overcome in some projects where, from the outset, neighborhoods had to propose themselves for improvement prior to inclusion in the program, as in Bolivia, but this is the exception and not the rule.

4.09 The distinction between the two types of shelter components can be applied to other regions as well and can lead to alternative solutions to cost recovery. In cities where the municipal tax system is relatively more developed than in Eastern African countries, such as Jakarta, it has been possible to use the property tax as the cost recovery mechanism. This solution has been viable because the unit costs of improvements have been small enough on a per capita basis to allow using municipal revenue for the program. This alternative is being considered for other cities, but it must be developed on a case-by-case basis in order to assure that some reasonable level of recovery is attained to permit future replicability. Increasing attention to municipal finance issues has been supported by extensive Bank research on this subject which is beginning to provide a framework for evaluating alternative approaches at the city level. 1/

4.10 Beyond shelter programs, cost recovery issues such as increases in bus fares or water tariffs have also proven to be difficult. Where project components are not sufficiently large, leverage has been lacking to obtain increases. A common example has been the pricing of water from standpipes in urban project areas. Nevertheless, increases in bus fares have been preconditions for processing of transport projects as in Calcutta, Bombay, and Madras and have led to major improvements.

4. Backsliding on Standards

4.11 A fourth issue which has affected the implementation of some projects has been an effort by agencies to design and provide services at higher standards than agreed at appraisal. After substantial debates over appropriate standards, some agencies have sought to revert to higher standards by changing designs from preliminary to final engineering, or even later during construction. In the Upper Volta project, a new government proposed to radically alter the standards, including the demolition of portions of the neighborhood to be upgraded. Firm action by the Bank involving stopping implementation until some agreement was reached was the only perceived alternative at the time. In other cases, construction loans or building types may be too large, implying that households should build overly large units all at once, rather than more modest dwellings over time.

4.12 In order to address these problems, urban staff now have a less doctrinaire attitude towards standards than in the past. Greater attention is focused on affordability of proposed solutions rather than their physical characteristics. Methodologies have been developed which permit better evaluation of alternative options for plot sizes and levels of infrastructure and which relate financial and physical criteria. 2/ Projects now include a wider range of plot options and service levels, permitting more heterogenous

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1/ For example, Johannes Linn, The Incidence of Urban Property Taxation in Developing Countries, a Theoretical and Empirical Analysis with Reference to Colombia, World Bank Staff Working Paper No. 264, 1977, and forthcoming book on municipal finance.

2/ See The Bertaud Model, A Model for the Analysis of Alternatives for Low-Income Shelter in the Developing World; Urban Development Department, Technical Paper No. 2, December 1981.

settlements and more politically acceptable standards. Over time, urban staff have also become more skilled in explaining the implications of infrastructure standards on project design and their impact on the pocketbooks of beneficiaries.

5. Project Management

4.13 Another group of implementation issues which have been found in many projects can be grouped under the term project management. These include steps such as the procurement of construction services, supervision, disbursement procedures within the country, allocation of serviced sites, scheduling of activities, settlement of households, and maintenance. The multiple tasks to be accomplished by project agencies requires effective "management" from the outset in order to master issues which are frequently internal to the executing agencies. These are certainly compounded by the difficulties of coordination with other institutions as suggested above. While there are many areas requiring improvement for almost every project, it appears that project management by itself has not been a determining factor in leading to major implementation problems. Increased attention by Bank staff to simplifying procedures wherever possible, for example in plot allocation where many countries require households to make numerous trips to various public agencies to obtain approvals and signatures, has significantly improved the management of project activities. Once procedures are simplified and implementation teams are in place, projects seem to progress reasonably satisfactorily. Supporting these efforts with training and technical assistance is useful in some cases, but in others it is apparent that projects seem to be implemented most effectively after expatriates are out of the way and local staff have full responsibility. This impression is supported by the evaluation of supervision teams as presented in Section B below.

6. Experience with Special Components

4.14 One area of particular difficulty has been the implementation of special components such as health, nutrition, and community development. Many projects have included the participation of community groups in the design and execution of neighborhood improvements. Urban projects have tried to encourage this process, probably more than any other sector of Bank lending. It was hoped that such participation would support important aspects of project design such as cost recovery, maintenance, and organization of social services through strengthened community cohesion. In some cases, community support has been an effective, though time-consuming input. In others, neighborhood politics proved to be extremely complicated and beyond the effective reach of the Bank and its intermediaries.

4.15 The implementation of social service components such as health and nutrition have also proven to be difficult, both for internal and external reasons. On the Bank side, urban staff lacked the technical expertise in these fields and the time to master their social dimensions within specific cities. In the countries, small components have been affected by the often confused and highly political character of social services in cities. Bank policy oriented towards preventive public health concerns has not been easily integrated into urban programs when the component is too small to provide adequate leverage. This experience has led to gradual simplification of projects, with special health and nutrition components limited to construction of clinics within project neighborhoods.

4.16 As noted above, the six problem areas discussed above represent only a partial view of the implementation experience of urban projects. They do not capture the variation across project types or regions, but rather focus on issues of importance in terms of the ultimate goal of urban lending: assistance to governments in establishing replicable programs for urban service provision. In order to complement the above qualitative picture of implementation, Section B will present the quantitative indicators commonly used in the Bank to assess implementation status.

B. Implementation Status of Urban Projects

4.17 Assembling the elements of a meaningful quantitative picture of the implementation experience of urban projects is difficult in view of data limitations. As noted earlier, only 14 of 62 projects have been fully disbursed, with 7 project completion reports submitted to OED. Implementation for the bulk of the portfolio is an on-going process. Evaluation is hindered by the fact that information on implementation is not complete. The adoption of the supervision Form 590 required detailed ratings for implementation status only since 1977, with earlier information available only in summary form. Despite these limitations, an effort has been made to classify projects by their implementation status according to supervision ratings as done throughout the Bank and then to look at specific aspects in the list presented above in greater detail. Where appropriate, comparisons are made with other sectors, such as in disbursement performance, in order to place the urban experience within the broader Bank-wide context.

1. Summary Status

4.18 Summary indicators from supervision reports provide the following picture for some 55 projects for which first year data were available. Initially positive ratings are made for the 55 projects, with only seven percent found in the "major problem" category. This pattern worsens somewhat in years two and three, with an improvement in the fourth year. While the data become of less significance in the outer years, there is nevertheless a general view that about 30% of the projects are relatively problem-free, while another 60% have moderate problems through the four years of implementation.

TABLE VI: SUMMARY IMPLEMENTATION STATUS

	Problem free- or minor Problems	Moderate Problems	Major Problems	No. of Projects
Projects in year 1 of implementation	47%	46%	7%	55
" " 2 "	22%	63%	15%	46
" " 3 "	17%	73%	10%	30
" " 4 "	32%	55%	13%	22

Source: Supervision reports.

4.19 This view is consistent with the general impression that start-up problems, mentioned above, have in some cases been severe, particularly in Africa, but once a team is organized and concentrating its efforts on the specific tasks of implementation, projects have progressed without exceptional problems. The regional breakdown of these ratings is presented below.

TABLE VII: SUMMARY IMPLEMENTATION STATUS BY REGION

Year of Implementation	1			2			3			4		
Status	1	2	3	1	2	3	1	2	3	1	2	3
East Africa	5	5			3	4	1	4		1	3	
West Africa	4	3	1	1	3	1		2		2		
East Asia	4	6	3	6	5		3	5	1	3	2	2
South Asia	1	4			3			3			3	
EMENA	2	3		2	2	1		2				
LAC	10	7		1	13	1	1	6	2	1	4	1
Subtotal	26	25	4	10	29	7	5	22	3	7	12	3
% Total	47%	46%	7%	22%	63%	15%	17%	73%	10%	32%	55%	13%

Note: The project rankings for the Form 590 are the following:

1. Problem-free or minor problems
2. Moderate problems
3. Major problems

While there are inevitable differences in the meanings of ratings from project to project and region to region, the overall picture is nevertheless instructive. It suggests that, despite some problem projects, the implementation ratings do not show abnormally high numbers of major problems in any of the first four years of implementation. A more detailed view of this experience is provided through the financial and project management indicators from Form 590.

2. Financial Indicators

4.20 The following financial indicators were analyzed for 37 projects approved during FY77-80: disbursements, estimated cost, anticipated completion, and project finances. These indicators were analyzed for each of the first four years of implementation, which is the limit on the number of years for which such detailed standard supervision reporting occurred. The results are presented in Table VIII below.

Table VIII: FINANCIAL INDICATORS FOR FY77, 78, 79, 80 PROJECTS
(% of Total)

	Disbursements	Estimated Cost	Anticipated Completion	Project Finances
Year 1 of implementation				
Status 1	56%	71%	67%	79%
2	26%	25%	25%	17%
3	17%	4%	8%	4%
Year 2 of implementation				
Status 1	31%	65%	54%	58%
2	69%	27%	35%	38%
3	19%	8%	11%	4%
Year 3 of implementation				
Status 1	47%	59%	35%	65%
2	41%	41%	41%	18%
3	41%	0%	24%	18%
Year 4 of implementation				
Status 1	38%	50%	25%	63%
2	25%	50%	50%	37%
3	38%	0%	25%	0%

Note: The project rankings for the Form 590 are the following:

1. Problem-free or minor problems
2. Moderate problems
3. Major problems

This table indicates that the greatest financial problem areas for implementation by the fourth year occurred in disbursements and anticipated completion, while estimated costs and project finances were in reasonably good shape. The financial indicators as a group suggest that project status deteriorated during the four years and that delays became more evident. They were not made up as might have been expected. Despite delays, project finances and estimated costs did not generate major problems, probably because projects were restructured and reduced in size in response to changing conditions.

4.21 The disbursement performance of urban projects has been a matter of concern for urban projects staff, as reflected in the supervision ratings given for disbursements for individual projects. As the following data will show, however, steps that are being taken to improve performance appear to be bearing fruit. When placed in a Bank-wide context, urban performance compares reasonably well with that in other sectors. On average, urban projects take about four years to reach the 50% disbursement mark and a total of eight years to be fully disbursed, roughly six months behind the Bank average. IDA credits tend to disburse slightly faster than Bank loans, probably because of the use of the Project Preparation Facility for IDA countries, which involves an immediate disbursement upon effectiveness.

4.22 For the purposes of this review, disbursement data were collected for all projects and compared to various previous analyses of urban performance. For example, the November 1980 Annual Review of Project Performance Audit Results includes a table presenting urban disbursements for a sample of 10 projects approved during FY70-74. These data were compared to a sample of some 34 projects approved in the next period from FY74-79, as presented below.

TABLE IX: AVERAGE NUMBER OF YEARS ELAPSED FROM EFFECTIVENESS TO REACH QUARTILE DISBURSED

	Number of Years Elapsed to Reach this Percentage Disbursed			
	25%	50%	75%	100%
Urban Projects Approved in:				
FY70-74	2.0	3.0	3.5	3.75
FY74-79	2.75	3.5	4.5	5.25

NOTE: For example, three years elapsed from effectiveness for projects approved in first half of decade to become 50% disbursed.

These data show that on the basis of a larger sample of projects, disbursement performance slightly deteriorated from the first to the second period, although these findings are limited by the size of the respective samples at each point. The second group of projects, however, is closer to the sectoral disbursement profile. A 1981 study on disbursements places urban in sixth place out of nine sectors, ahead of water supply, agriculture, and education and only slightly behind transportation and telecommunications. The urban position is a bit clearer when graphed against other selected Bank sectors and the Bank average as indicated in Figure 1. This graph shows that urban is quite close to the overall Bank disbursement profile.

4.23 In order to go beyond the overall disbursement profiles for urban lending, analysis was also undertaken of disbursement patterns by project type. This analysis is limited by availability of data, however, two general observations can be drawn from the following table:

(a) Urban shelter projects have tended to disburse about half as fast as urban transport and integrated urban projects.

(b) Integrated urban projects have tended to disburse fastest of all three project types, probably reflecting the strong performance of South Asia projects.

TABLE X : ESTIMATED AND ACTUAL DISBURSEMENTS BY PROJECT TYPE
In first three years of implementation
(% Disbursed, Cumulative)

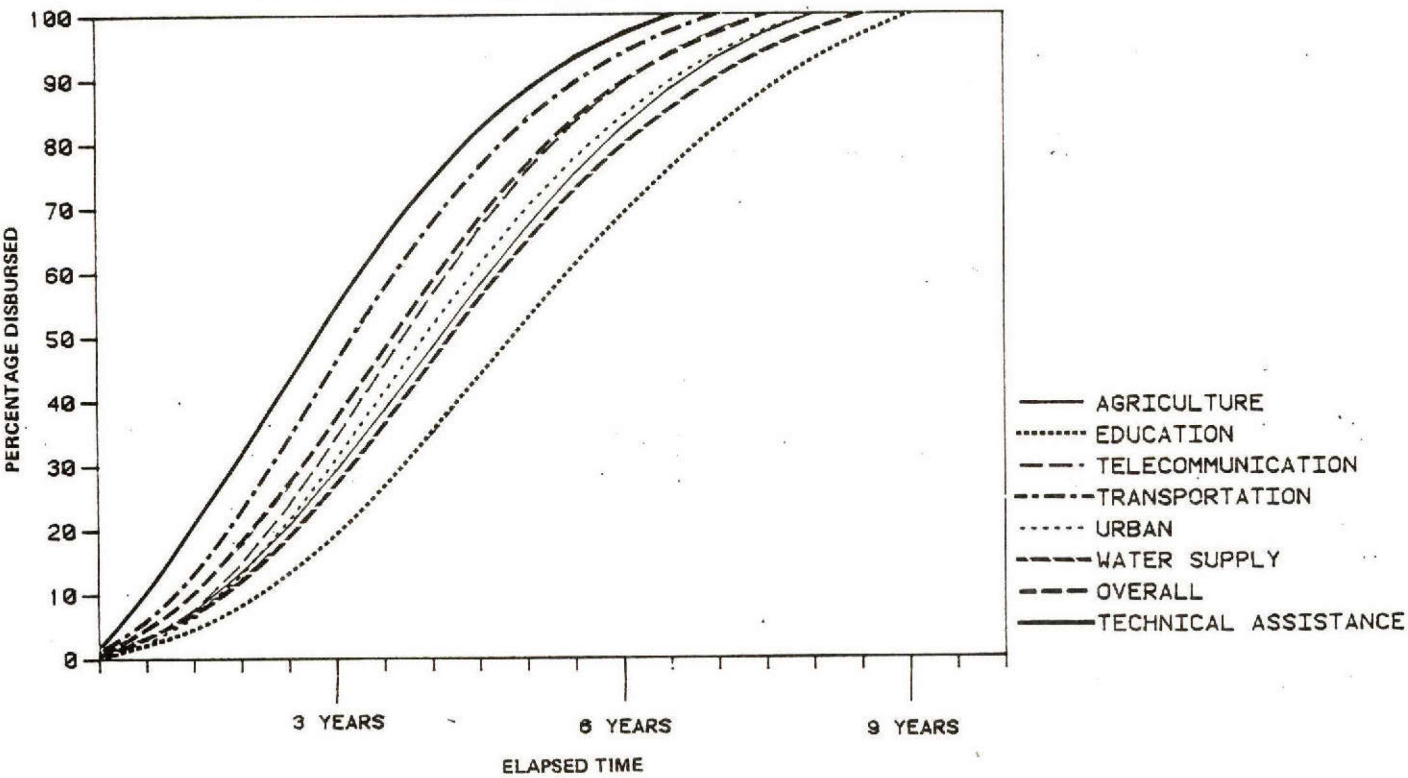
Year of Impl.	Sites and Services			Transport			Integrated Urban			Regional Development		
	Est.	Act.	No. of Proj.	Est.	Act.	No. of Proj.	Est.	Act.	No. of Proj.	Est.	Act.	No. of Proj.
1	21.8%	6.2%	25	21.2%	9.2%	6	18.6%	3.7%	11	20%	5.5%	2
2	60.0%	18.3%	17	60.1%	21.7%	6	52.4%	22.9%	7	-	-	-
3	84.2%	26.0%	11	93.1%	42.5%	4	80.2%	47.5%	4	-	-	-

Note: The information in this table was compiled from recent disbursement data. Only projects for which complete data were provided are included here.

4.24 Disbursement findings are also related to delays in anticipated date of completion. This indicator, like disbursements, showed that problems were not satisfactorily resolved by the fourth year of supervision. However, it is premature to determine how many projects have actually been delayed. According to OED, the average Bank project is delayed by 40%, with implementation extending from 3.8 to 5.4 years. It is not yet possible to determine statistically whether the urban pattern fits into the Bank norm. Nevertheless, the average of eight years required to complete disbursements suggests that the initial implementation schedules, which were typically three years for projects prepared before FY79, were very unrealistic. This has been a major concern to the regional project departments. Recent efforts to link implementation schedules to sectoral disbursement profiles may help to make implementation schedules more realistic.

FIGURE 1

DISBURSEMENT PROFILES OF SELECT SECTORS: AGRICULTURE, EDUCATION, TELECOMMUNICATION, TRANSPORTATION, URBAN, WATER SUPPLY



3. Project Management Indicators

4.25 The following indicators of project management were analyzed for the 37 projects: compliance with loan conditions, management performance, and procurement. The indicators, as presented below in Table XI, reflect start-up problems as suggested above. Over time, the management of urban projects appears reasonably satisfactory at the project level. However, this indicator may be somewhat illusory, given the experience found in projects across the regions. No major problems were identified by the fourth year of implementation for compliance with loan covenants, despite earlier indications of problems. Early problems with management performance, usually associated with the start-up period of projects, seem to have improved substantially by the fourth year of implementation. Similarly, procurement problems were also resolved by the fourth year. While these project-level perspectives indicate satisfactory performance, they do not suggest that project management issues will be necessarily easy to handle as project scale increases. The issue of institutional development, therefore, remains despite these successes at the project level.

Table XI: PROJECT MANAGEMENT INDICATORS FOR FY77, 78, 79, 80 PROJECTS
(% of Total)

	Compliance with Loan Conditions	Management Performance	Procurement Process
Year 1 of implementation			
Status 1	58%	46%	86%
2	33%	46%	13%
3	8%	8%	0%
Year 2 of implementation			
Status 1	62%	38%	58%
2	27%	54%	42%
3	11%	8%	0%
Year 3 of implementation			
Status 1	59%	29%	71%
2	35%	59%	24%
3	6%	12%	5%
Year 4 of implementation			
Status 1	63%	63%	100%
2	37%	25%	0%
3	0%	12%	0%

Note: The project rankings for the Form 590 are the following:

1. Problem-free or minor problems
2. Moderate problems
3. Major problems

C. Toward an Interim Evaluation

4.26 Taken together, quantitative indicators from supervision reports suggest that aside from problems in disbursements and delays in making project activities start-up, urban projects receive a relatively positive evaluation. Project officers, through the use of the ranking "2", acknowledge moderate problems in implementation, but the trends through the first four years of implementation show improvement by the fourth year. The problems which are identified fit within overall patterns identified by OED which suggest areas for improvement, with the most important being greater realism in scheduling of activities. This seems to apply to both simple and complex projects, although complexity by itself requires greater coordination which may delay implementation.

4.27 In contrast to the above quantitative picture, the problem areas identified in Section A suggest that establishing the foundation for program replicability will require continued attention. Issues such as an effective institutional framework for urban development, procedures for land acquisition, improved cost recovery, agreements on appropriate standards, effective project management, and simplification of projects to facilitate achievement of primary objectives will continue to be important during implementation of subsequent projects. Experience with second projects suggest that encouraging progress on these issues has been made during the first project period. In countries where third and fourth projects are under implementation, such as Indonesia or Philippines, implementation issues have become much more specific at the agency and city level where they can be effectively addressed. As such, implementation reflects a learning by doing process within the countries as well as the Bank.

V. MANAGEMENT OF URBAN OPERATIONS

5.01 Previous sections have described the challenges posed by urban growth, by policy differences with countries, and by difficulties in developing technical solutions to urban problems. Another type of challenge was also posed by the lack of urban experience of Bank staff, consultants, Borrowers, and the Bank as an institution. The management of urban operations over the past decade has had a particular character as a result: it has relied on training and on the development of its own style in order to mobilize staff, attract the attention of Borrowers, and develop working relationships with other parts of the Bank at a time when expansion was occurring in many sectors. Most urban staff agree that the experimental period up to the start of regionalization was challenging for project teams, Divisions, and the Department as a whole. As urban operations have been gradually regionalized, adjustments are required as urban staff begin working more closely with regional programs and projects divisions. This process appears to be proceeding well, as reflected by the more than 90 urban operations under consideration and preparation for FY82-86, a more than doubling the annual number of projects in past years. This suggests that despite the unresolved issues in project design and implementation, urban will increasingly become a significant sector of lending, particularly in Asia, Latin America and the Middle East. This section will describe the management experience of urban lending, pointing out some of its salient features and fitting the urban experience into broader Bank-wide concerns.

A. Staff Development and Training

5.02 One of the most noteworthy features of the Bank's urban lending experience has been the rapid development of staff experience and expertise. The Bank began urban operations with a very small number of staff in 1971, which grew rapidly, as shown in Table XII. By July 1981, six regional urban divisions had been created and transferred to the Regional Projects Departments. A large number of staff were trained in Bank procedures and approach during the period.

TABLE XII: PROFESSIONAL STAFF WORKING ON URBAN PROJECTS 1/

FY	No. of Professional Staff
71	10
72	15
73	25
74	36
75	45
76	46
77	50
78	53
79	62
80	73
81	83

1/ Does not include transportation and tourism staff working in the Urban Projects Department at various times.

Some 28 staff-years of Young Professionals are included in the above number of professional staff-years, which means that approximately 56 Young Professionals were also introduced to the Bank through the Urban Projects Department.

5.03 The above expansion is significant in several other respects. Many staff recruited for urban work came from outside the Bank. The required personnel included architect-planners interested in low-cost design, engineers with experience in basic urban infrastructure, economists familiar with urban economics and particularly the characteristics of poverty populations, and financial analysts with experience in municipalities and housing institutions. Few of these backgrounds were available in the Bank and, as the Department learned over time, it was often difficult to identify people with appropriate backgrounds and interests on the outside. This situation was complicated by the fact that the needed mix of skills also changed as project design evolved. Whereas architects and engineers were in great demand at the outset, they became less important when projects shifted towards institutional and broader financial questions. Personnel experienced with municipal maintenance, employment generation, and social services in developing countries proved to be difficult to find. While those recruited often brought excellent skills and field experience, they were unfamiliar with the Bank and the project cycle. This resulted in the perception of some staff that they were being pushed into operations before they were fully acquainted with their employer. This situation was reflected in some projects in which preparation and appraisal efforts were led by technically qualified staff who had to learn more about the Bank's internal procedures than the problems to be addressed by projects. Inside the Bank, this lack of experience with internal procedures and policies on occasion led to problems in coordination and communication, thereby creating "image problems" for some urban staff.

5.04 Another aspect was training for management itself. Mission leaders were often in their early 30's, with usually not more than two years of Bank experience before they were asked to lead missions. Training mission leaders in mission management and organization of project preparation proved to be a priority task. Extensive travel by Division Chiefs and Front Office advisors supported less-experienced staff. As urban operations grew, there also was a need to train urban staff to take on management responsibilities. This is reflected in the number of Division Chiefs, four of six, and Deputy Division Chiefs, four of five, who have come from urban projects divisions. The various recombinations of regional divisions assisted this process as many staff were required to work in more than one or two regions, although very few have worked in more than three.

B. Internal Procedures

5.05 An important part of the Department's approach to staff development and training concerned internal procedures intended to maximize learning and delegated responsibility. These included Front Office Travel, the internal review process, project budgeting, and manpower planning for missions.

1. Front Office Travel

5.06 Given the evolution in project design and the understanding of urban issues, there was from the outset a problem of communicating the most recent "state of the art" concerning specific issues, ranging from infrastructure design to cost recovery policy to differential pricing. Departmental expertise for some components, such as business support or health and nutrition was severely limited, requiring a few staff to work on a large number of projects. In order to supplement individual preparation efforts, extensive travel was undertaken by Front Office personnel, including the Director, during various stages prior to and at appraisal. This policy resulted in improved understanding by the Front Office of individual urban problems and improved understanding of current policy and practice for project officers.

2. Internal Review

5.07 Field support was continued at headquarters through briefings prior to appraisal missions and selected preparation and supervision missions, when missions met with the Director and Advisors to discuss critical issues likely to be faced during appraisal. Missions consequently were able to take positions on issues which had been fully explored prior to their departure. This process set the stage for the major review of the project cycle--for white cover appraisal reports--which became the single most important vehicle for discussion, debate, and communication of Departmental policy. White cover review meetings for early projects frequently lasted a whole day, on occasion took two days, as both the content and presentation of appraisal reports were critiqued. Representatives from each of the urban divisions attended these meetings to discuss and decide such issues as whether the costs of off-site infrastructure would be recovered, how land was to be treated in calculation of total project costs, how affordability and poverty impact were to be measured, how economic rates of return should be calculated, and many other issues which evolved in establishing the approach to different project types. These meetings served as an important forum for practical policy development and staff training.

3. Project Budgeting

5.08 A third internal procedure concerned the Front Office decision to delegate management of budgets for operations to Divisions and they in turn to project officers. An elaborate, if somewhat tedious system was developed which required project teams to plan out their manpower needs within a budget framework which would be aggregated at the divisional and departmental levels. This process devolved management responsibility for individual projects to project officers and permitted the rapid expansion of the program.

4. Manpower Planning for Missions

5.09 A related internal procedure was the general practice of delegating decisions for manpower planning for missions to the project officer. In effect, project officers were responsible for organizing their teams, using consultants as well as staff. By 1978, a pattern had emerged where each division had a "stable" of experienced consultants who were used on a regular basis. Two years later, many of them had joined the Bank staff in these same divisions. The continuity of personnel, first as consultants and then as staff, helped overcome some of the problems of rapid expansion, although continuity still remains a problem in some regions.

5.10 While these procedures were not in themselves determinant of urban operations, they reflected a "style" which stimulated individual staff and created an "esprit de corps" during the period of rapid growth.

C. Performance Indicators

5.11 It is within this context that the indicators of urban performance should be evaluated. Some of the standard Bank indicators include the following: staff weeks from identification to Board approval, elapsed time for the same period and beyond to effectiveness and first disbursement, and supervision coefficients. Data on these indicators suggest that starting from rather high coefficients characteristic of lending in new sectors, urban operations have been processed in less time and with less staff input as experience is obtained within the Bank and Borrower agencies. Urban indicators fit within the norms of Bank operations. By themselves, however, they do not provide a justification for one type of operation or another. That justification necessarily must be based on the problem to be addressed in specific countries and the benefits that a given project is likely to generate.

5.12 The following summary findings have emerged from a detailed analysis of processing and performance over the ten-year period:

(a) FY81 urban operations have been prepared, appraised, and presented to the Board in about 20 months, compared to the average Bank project which takes about 27 months from identification to Board presentation.

(b) Processing of urban operations from appraisal to Board compares favorably with regional averages which, for example, is 13.3 months for all sectors in Eastern Africa and 11 months for urban operations in FY81.

(c) The elapsed time from Board approval to effectiveness and to first disbursement has declined substantially, demonstrating that conditions of effectiveness are no longer slowing down the start-up process as occurred in the early years.

(d) The processing of urban operations from identification to Board presentation on average required 176.5 staff-weeks per project. The ten-year urban average, however, masks large differences between urban shelter (158.7), transport (143.5), integrated urban (219.9), and regional development projects (299.4). These averages by project types further mask the fact that substantial efficiencies have been achieved in some regions, such as Eastern Africa and Latin America which reached 104 and 88 for FY80-81 projects respectively. Both of these levels are below the average Bank project and demonstrate that, as experience is gained within the Bank and with Borrowers, urban operations increasingly conform to Bank norms.

(e) Analysis of supervision coefficients suggests that while they remain high beyond the fourth year of implementation, they should be considered in terms of the technical assistance provided to Borrowers who lack experience with the approaches under implementation. Coefficients are expected to decline as the majority of first projects are completed.

(f) There are significant differences in the supervision profiles according to project type, with initial shelter projects requiring high levels into the eighth year, while transport and integrated urban projects drop sharply after the third and fourth year respectively.

D. Working Within Bank Constraints

5.13 These findings suggest several important observations about the evolution of a new sector of lending within the Bank context. The process of introducing new approaches to Borrowers within a programmatic approach involves substantial effort. The strategy of urban lending in most countries focused on starting off with a sub-sectoral project, such as urban shelter, as the first in a series of operations intended to establish an "urban" perspective on the management of the sector. Numerous technical problems had to be overcome on initial projects, yet the larger objective of working with the government to establish a coherent approach to the sector as a whole remained central for most supervision teams. The combination of supervision and technical assistance has moved Borrowers towards this larger objective through time and in fact has proved to be the motive force in establishing a pipeline of projects. In regions where this has been successful, as in East Asia and Latin America, major Borrowers are now capable of implementing one urban operation per year. It is thus possible to capture the efficiencies in processing with these Borrowers. In some cases, urban operations are moving towards sector lending, much like the Industrial and Development Finance project model where the Bank has shifted from retail to wholesale and managed to reduce the costs after a decade of operations.

5.14 An important aspect of the process is the recognition of Bank constraints. Regional projects departments have sought to reduce urban coefficients to levels of other sectors, sometimes without taking into account the objectives of urban lending and the historical view which is suggested above. It is clear that such efficiencies are being achieved according to country situations, the maturity of the Borrower agency, and the experience of Bank staff. There will, therefore, be regional variations in coefficients according to these factors.

5.15 It is nonetheless apparent that further efficiencies have to be sought; they will come only with effort. Regionalization offers an opportunity to take advantage of better country knowledge, coordination, and regionally-specific management of resources. This opportunity should provide some significant returns in terms of divisional resources, both to the input side, in preparation and processing, and the output side through more effective supervision as the numbers of projects increase and economies of scale are achieved. In a real sense, regionalization forces urban divisions to compete with other sectoral divisions, applying the same criteria of affordability used in projects to urban operations themselves. Expensive projects may be justified in terms of their impact, but undertaking them will require explicit choices and better management of the entire urban portfolio, much like a household budget. The regionalization process has gradually impressed this fact on urban staff and it should be expected that efficiencies achieved to date can be maintained and improved upon.

VI. THE IMPACT OF URBAN LENDING

6.01 Previous parts of this review have examined the process of policy and program development, project design, and management of operations. The most important criterion for evaluating this experience is the impact of the Bank Group's urban activities on the national policies of governments in the urban sector. Evaluating this impact, however, is a complicated task. Assisting governments and local authorities to move towards an "urban perspective" rather than a partial, sub-sectoral view, was always expected to be a long-term objective. Progress towards that objective would necessarily vary across countries, with many political, economic, and institutional factors influencing the Bank's impact. The Bank's primary objective was therefore translated into a series of secondary, operational objectives which would be reflected in project activities and sectoral dialogue over time. Given the relatively short duration of urban lending, at most ten years but considerably less in many countries half of whose projects were financed after 1977, it is without question too early to evaluate progress in terms of the Bank's primary objective. It is possible, however, to review progress in relation to the secondary objectives. An interim evaluation of those achievements is the subject of Part VI. Subsequent pages will draw on data sources such as supervision reports, project completion reports, and monitoring and evaluation studies in order to present a view of progress towards the secondary objectives which were:

(a) to demonstrate low-cost technical solutions for shelter, infrastructure, and transport which were affordable to the urban population;

(b) demonstrate that it was possible to provide services for the urban poor on a non-subsidized basis;

(c) to demonstrate the feasibility of moving over time from subsectoral points of entry (such as shelter projects), to comprehensive "urban" planning and investment programming procedures suitable for rapidly changing urban conditions; and

(d) to demonstrate the replicability of the above solutions within a long-term institutional and financial framework.

6.02 As suggested earlier, this progress is evident in many different areas, from policy to program to direct benefits on urban households. This section will therefore present this range of impact by reviewing indicators of the following impacts:

(a) Impact on national policy in the urban sector or sub-sectors

(b) Approaches to project design, planning, and investment programming

(c) institutional development

(d) policy and program impact in specific cities

(e) direct project benefits, including poverty impacts

(f) impact in the development assistance community

A. Impact on National Policy in the Urban Sector or Sub-Sectors

6.03 At the most general level, the Bank's urban activities to date are demonstrating to Borrowers that it is possible to apply economic, financial, and technical methods of analysis to develop solutions to urban problems which do not distort other sectors of development. This is an important contribution because it has begun to change the impression that the urban sector is necessarily a privileged enclave within national economies. Instead, the Bank's approach acknowledges the major concerns about the place of the sector in development strategies and is developing an approach which takes many of them into account. From the macro-economic perspective, the approach accepts the importance of the rural sector and insists that, in financial terms, the urban sector should pay for itself through cost recovery. Urban project design is based on the assumption that investments in improving urban living conditions should improve urban productivity and should be done without taking away scarce resources needed for rural development. At the sub-sectoral level, the approach suggests an alternative to conventional public housing, reducing the financial burden on the public institutions. The sites and services approach answers many of the criticisms of inappropriate architecture and planning, by turning over these responsibilities to the beneficiaries themselves and accepting the need for progressive solutions over time.

6.04 Demonstrating that it is possible to develop affordable solutions for the poor has changed the terms of discussion on an important aspect of urban policy affecting the majority of urban dwellers in countries, such as

India, Nigeria, Philippines, and Bolivia. The practical feasibility of such approaches, reflected in the fact that households have invested in their shelter once tenure was secure and services available, has opened up many new possibilities for sectoral policy at the national level. Many governments are now aware that if existing obstacles such as unaffordable building codes or zoning regulations are eliminated and tenure assured, households will respond to less regulated environments by investing in urban shelter, often to an extent far beyond what their income levels would suggest possible. Projects which create new opportunities for this investment, such as Dandora in Nairobi or Arumbakkam in Madras, are producing results which demonstrate the vitality of the urban poor. Whether one uses detailed survey instruments as in the IDRC-IBRD evaluation studies or casual empiricism, it is apparent that the so-called progressive development model, i.e., that households will improve their housing over time, works in practice.

6.05 This finding applies in new developments or in upgrading of existing neighborhoods as in the kampungs of Jakarta or the compounds of Lusaka. Its impact on the policy thinking of governments has been noticeable in many countries, ranging from Indonesia to Botswana where projects have worked well, to countries where projects have not been implemented smoothly, as in Senegal which has adopted the sites and services approach because other more expensive programs were unaffordable, both for public agencies and the intended beneficiaries. Even in countries where projects have not yet been financed by the Bank, such as Algeria, the new policy approach to shelter has been reflected in nationally-financed programs. Publicly constructed housing, the model of the 1950's and 1960's, has given way to private investment through self-help, thereby reducing the role of the public sector. The list of countries which have moved in this direction includes Thailand, Mali, Ecuador, Brazil, Kenya, Tanzania, Tunisia, Morocco, Jordan, Lesotho, and Burundi. More detailed discussion of impacts will provide examples from these countries.

6.06 While impact on national policies for urban transport is less clear, in part because there have been fewer projects and as illustrated above, there has been a less focused approach to the sub-sector, it is nevertheless apparent that a significant number of governments are coming to realize that heavy investment in transport infrastructure can be postponed if existing facilities are more efficiently utilized, as in Costa Rica. Countries such as Ivory Coast, Thailand, Kenya, Brazil, and India are using "affordable" solutions in urban transport in some cities which are less costly than technical approaches used in developed countries in earlier periods. The concept of traffic management is an example of technology transfer which can have a profound effect on national investment in the urban sector. Traffic management schemes have produced high rates of return by improving traffic speeds, increasing volumes, while reducing accidents, and also through savings achieved in transport investments.

6.07 While there are other indicators of the national policy impact of the Bank's urban activities, many of these are found at the institutional level, with new approaches, procedures, and deployment of manpower and resources.

B. Approaches to Project Design, Planning, and Investment Programming

6.08 At a more concrete level of impact, major changes have occurred in the following areas of design of urban shelter and transport projects: design standards, cost recovery, reaching the poor, providing land tenure, and design procedures.

1. Design Standards

6.09 Government policies concerning "acceptable" design standards for shelter and infrastructure projects are being influenced in many countries. In Nigeria in 1978 at the time of appraisal, the cheapest house financed by the public sector cost US$40,000. The shelter unit included in the first Nigeria project was estimated to cost US$1,600 or four percent of the previous type. An October 1981 supervision mission reports that units built in Bauchi, Nigeria fit within appraisal estimates. Public housing in Madras, India cost about Rs. 12,000 per unit in 1976. The first Madras project has provided units at Rs. 3,000 per household, even with an interest rate of 12% which is about three times the prevailing interest rate for low-income housing in India. Many of the cost savings which have been achieved result from more efficient land use and reductions in standards for individual infrastructure works. The impact on reduced standards has meant that many governments now realize that it is possible to provide acceptable low-cost shelter and infrastructure at affordable unit costs which do not require public subsidies. There are no longer technical excuses that it is impossible to design services for the poor. Sites and services and upgrading have consequently become the "new orthodoxy" in some countries, as evidenced by the conclusions of participants in the 1980 Economic Development Institute Urban Projects Course for francophone countries in Abidjan that "sites and services is the only solution", certainly an overstatement but nevertheless an indication that a major shift in thinking had occurred.

2. Cost Recovery

6.10 A corollary of reduced standards and costs has been the fact that governments now can recover the costs of urban services if they have the political will and administrative capacity to collect. As noted in Part IV, the East Africa cost recovery paper demonstrated that despite the setting of ambitious cost recovery targets, the cost recovery performance of sites and services components was initially satisfactory but suffered when follow-up measures such as maintenance did not occur. These problems became more severe in countries lacking administrative capacity at the local level. Recovery for upgrading in various projects including Zambia and Madras has not been as expected. Further effort will be necessary to devise procedures for recovery in upgrading approaches. The example of the upgrading program in Indonesia, which does not include direct recovery but relies on city-wide tax revenue to finance the program, has proven feasible in part because of the low investment cost of about US$37 per capita. This approach, also adopted in Thailand, allows longer-term replicability, but suggests that broader municipal finance approaches will be necessary for recovery.

6.11 Urban transport projects have also achieved higher levels of cost recovery, as in the case of fare increases for bus companies in cities such as Madras, Calcutta, and Bombay. Efforts to improve financial management for these companies have raised broader issues of fleet expansion and supporting facilities which have resulted in more efficient links between costs and pricing. The most dramatic case of cost recovery in urban transport was the area licensing scheme in Singapore which was not a Bank-financed scheme, but which was carefully monitored by Bank staff. For numerous organizational and political reasons the scheme has not been replicated elsewhere. However, the experiment has added a new dimension to discussions of financing the transport sector. 1/

3. Reaching Low-Income Groups

6.12 A third related policy impact concerns governments' new-found capacity to provide services for the poor. Institutions such as housing banks and corporations now can reach the poor if the political will exists. Projects in Brazil, Botswana, Thailand, and Tanzania, among many others, have demonstrated that it is possible to design projects that reach the first decile in the income distribution in upgrading. For example, in the latter case, the Tanzanian Housing Bank has lent about 60% of all loans to households with monthly incomes below US$120, of which 75% are to those below US$85. In addition to reducing standards and costs, projects have used differential pricing to provide services at affordable levels. In India, this has meant a new approach to public programs in several states and the national government's decision to direct the Housing and Urban Development Corporation's programs towards the Bank's approach.

4. Providing Land Tenure

6.13 As noted earlier, land tenure was identified as a major target for policy impact at the outset of Bank lending. Without secure tenure, households would not invest their own limited resources in housing. Changes in land tenure by insisting that existing settlements be legalized has resulted in major changes in the Bank's member countries. These projects have, in fact, been "urban land reform" programs in cities where land issues have been among the most political questions. The bulldozer has been replaced by the deed or long-term lease as the leading instrument for land policy. This impact cannot be emphasized enough, because its potential impact on income distribution and welfare is enormous. Moreover, this process has occurred in almost every one of the projects having shelter components.

5. Changes in Design Procedures

6.14 If the content of approaches to project design have changed as a result of Bank activity in the sector, there have also been changes in the design process itself. These changes, identified by urban projects staff working in South Asia, include the following:

1/ Peter L. Watson and Edward P. Holland, Relieving Traffic Congestion: The Singapore Area License Scheme, World Bank Staff Working Paper No. 281, June 1978.

(a) Broader and less compartmentalized planning, bringing together physical, economic, and financial considerations in investment programming.

(b) More iterative and less sequential planning processes, in which goals and instruments are more carefully related.

(c) Exploration of a wider range of alternatives in the choice of technical solutions, thereby linking technology and cost more explicitly.

(d) Use of affordability in establishing parameters within which technical solutions are found.

(e) Adoption of programmatic planning approaches, relating individual projects to the scale of the problem to be addressed, thereby permitting more realistic goals to be set, particularly in phases over time.

These changes are found in organizations such as the Madras and Calcutta Metropolitan Development Authorities, the Project Development Department of the Federal Mortgage Bank of Nigeria, EBTU (Empresa Brasileira dos Transportes Urbanos) in Brazil, the Banco del Vivienda in Ecuador, and the Ministry of Housing in Morocco. While some agencies would assert that they shared the above before involvement with the World Bank, there is nevertheless a general observation that these improvements have occurred over the past decade--a decade in which the Bank has played a leading role in the evolution of urban development thinking and practice--thereby permitting steps toward sector lending and greater national responsibility for preparation and appraisal of urban operations.

C. Institutional Development

6.15 A third measure of impact of projects concerns their success in strengthening institutions within the urban sector. Changes in policy and approach have occurred as a result of the Bank's urban operations. Implementing those changes required reorientation and strengthening of many institutions, from the national to local levels. Institutional development in fact became the leading priority once agreement has been reached on policy directions. It also has proven to be a difficult task, both because of inherent human and political factors and the difficulties of improving internal organization, procedures, and staff while at the same time asking institutions to take on new roles and responsibilities. Moreover, institutional development is not a short- or medium-term goal, but necessarily occurs over time, with a gradual increase in capacity to formulate policy, plan, budget, and carry out programs.

6.16 The problem of institutional development in the urban sector is also characterized by several special features. Firstly, there has been a proliferation of institutions operating in urban areas, each with sub-sectoral responsibilities within individual cities and towns, yet frequently lacking overall coordination. Institutional approaches to urban development must address the need to improve individual performance within a coordinated framework. A second characteristic is that municipalities, usually the only institutions with jurisdictional responsibility for many sub-sectors within a city, have traditionally been the backwaters of the institutional scene. In most countries and within various colonial traditions, municipalities have been poorly staffed, insufficiently financed, lacked qualified staff, adequate revenue, and effective control over their areas of responsibility. National level institutions frequently undermine municipal efforts to achieve greater autonomy, particularly in financial terms, yet at the same time refuse to finance needed local improvements. Urban investment programming becomes a difficult task, relying on changing priorities within sub-sectors at different institutional levels. If the capital development side is uncoordinated, the recurrent financial and technical responsibilities for operations and maintenance are equally unsatisfactory in most cities.

6.17 Given the above, it is certainly premature to evaluate the impact of urban operations on institutional development. If acceptance of new policy objectives and implementation of new types of projects can be taken as proxies for improved institutions, some progress has already been achieved. Only in cases, however, where institutions themselves have taken on increasing responsibilities for developing projects in a programmatic context can it be said that real "development" has occurred within the organization. This pattern is beginning to emerge as urban operations begin sector lending in various countries. For example, in countries as diverse as Indonesia, Philippines, Peru, Nigeria, India, Thailand, Korea, and Brazil, experiments are underway with agencies identifying, preparing, and in some cases, appraising components of Bank-assisted projects. Typically Bank appraisal missions are focusing attention on several towns, leaving programs in others to be prepared and appraised by the executing agencies. In so doing, the Bank is switching from retail to wholesale in urban operations. The decision to experiment in this way assumes that national institutions now have the capacity to translate technical findings into investment packages and sub-projects. As with the IDF model in development banking, criteria have to be developed and procedures adopted which assure Borrower maintenance of necessary quality and viability. However, the evidence to date suggests that these experiments are working reasonably well. Ultimately, the test for institutional development will be whether such programs can be sustained without external assistance, which is in the best interests of the country and the Bank.

D. Policy and Program Impact in Specific Cities

6.18 A fourth type of impact resulting from Bank urban operations has occurred at the city level in many countries. Two types of impact can be identified: (i) city-wide, cross-sectoral impact as a result of improved urban planning, investment programming and management; and (ii) city-wide, single sector impact as a result of improved policy and program design. The first of these impacts has occurred in cities such as Calcutta and Manila, where single or multiple operations have resulted in new integrated approaches to city-wide investment. Two projects in Calcutta have significantly improved the physical environment in the city as a whole, through many relatively small improvements and/or extensions of infrastructure networks. Most importantly, the Calcutta Metropolitan Development Authority (CMDA) has developed as an effective investment agency. An early shelter project in Manila, the Tondo Foreshore Project, has led to several subsequent operations and substantial dialogue between the Bank and the various institutions involved in the sector, including the National Housing Authority and the Ministry of Human Settlements. These discussions have given birth to concepts such as the Capital Investment Folio (CIF) which is intended to coordinate investments in the Metropolitan Manila region. Other efforts to develop city-wide frameworks, as in Abidjan with the ten-year development study and strategic investment program and in Tunis with the creation of the District of Tunis, have been less successful, but have nevertheless provided a broader "urban" perspective for development for those cities.

6.19 The second type of impact, a city-wide, single sector impact, has occurred in Jakarta through the successful Kampung Improvement Program (KIP) which has improved basic infrastructure for millions of people over the past eight years. A programmed application of a proven technical solution has resulted in widespread benefits which have now been extended to other cities in Indonesia. Another example is in Madras, where two projects have increased the capacity of two shelter agencies, the Tamil Nadu Housing Board and the Tamil Nadu Slum Clearance Board, to provide sites and services and slum improvements respectively. By 1981, the production of serviced sites has reached 5,000 per year, with the likelihood that by 1983-84, this level will more than triple to some 18,000 units a year. At the same time, slum improvement programs are now reaching some 10,000 households each year and expect to rise to 15,000 per year. Most importantly, success with these programs has led the state government to shift funds from conventional programs into sites and services and slum improvement schemes, thereby reducing overall unit costs while increasing the coverage of the program. The foundation of the sites and services program, cost recovery, has been quite successful, with only five percent defaults. In addition, new revenues created by shelter programs, earmarked for maintenance by local government and service agencies, have grown by some Rs 7 million crores per year, or 40% of the previous year's municipal revenue thereby providing an important new sources of municipal finance for the city. 1/

1/ Additional impacts in Madras include financial strengthening of the Pallavan Transport Company, better planning by the Madras Metropolitan Development Authority, and improved management of the Madras Municipal Corporation.

6.20 Single sector, city-wide impacts have also occurred through urban transport projects, such as Tunis, where a combined program of traffic management, bus purchase, suburban rail reconstruction and institutional development has managed to improve public transport service, despite large increases in private car ownership, usage, and overall mobility. Specifically, bus availability (outshedding) in Tunis increased from 60% in 1973 to 82% by 1980. Bus breakdown declined from 6.5 per 10,000 km in 1974 to 1.8 per 10,000 km in 1980. At the same time, bus ridership increased by 70% or 7.9% annually, loadings decreased by 25%, while network coverage and the bus fleet expanded 100% and 69% respectively. These are impressive results in a city where some 70% of trips were by foot in 1970. Mobility has been increased significantly. Other impacts came from the introduction of busways, as in Abidjan, which carried some 26,000 passengers per hour and reduced travel time by 50% within six months of operations, even before traffic signal controls were operating.

6.21 There are other examples of city-level impacts, such as the upgrading programs in La Paz, Bolivia and Lusaka, Zambia; the land registry system in Bamako, Mali; and rehabilitation of social services in Ouagadougou. Many other activities are in progress, are of a longer term nature, and are yet to be documented. It is nonetheless clear, however, that Bank urban operations are improving living conditions and management of a large number of cities in Borrower countries.

E. Direct Benefits

6.22 While it is difficult to collect data on ex post benefits which have resulted to date from urban projects, given their recent origins and status of implementation, it is nonetheless possible to present indicators of anticipated benefits to suggest the order of benefits likely to be provided. Three of these indicators are the estimated economic rate of return, the number of urban households likely to receive direct benefits through improved shelter, water supply, sanitation, and social services, and the percentage of total project costs providing direct benefits to the urban poor.

1. Economic Rate of Return

6.23 Table XIII presents the average estimated economic rate of return at appraisal by project type for each of the fiscal years of urban lending.

TABLE XIII: AVERAGE ECONOMIC RATE OF RETURN BY AVERAGE TYPE

FY	Sites & Services	Transport	Integrated Urban	Regional Development
FY72	n.a.			
FY73	9.5 (2)	37.0 (1)	10.0 (1)	
FY74	12.7 (2)	19.5 (2)		
FY75	16.4 (5)			28.0 (1)
FY76	28.5 (2)	30.0 (1)		
FY77	38.5 (2)	28.0 (1)	32.0 (2)	
FY78	21.3 (7)	34.0 (2)	17.3 (4)	
FY79	46.7 (3)	28.0 (1)	23.8 (4)	
FY80	17.6 (7)	23.0 (1)	21.0 (1)	23.0 (1)
FY81	17.9 (5)	50.0 (1)	22.0 (1)	14.0 (1)

These data show that estimated rates of return have been high across the project types, even though the small number of projects per fiscal year influences the averages considerably. The yearly averages for all project types demonstrate a consistently high level, even though there is some variation, for example in FY79, when a few projects produced very high estimated rates of return. Urban transport and integrated urban projects are the most consistent in maintaining their levels of return. The major finding of this table is that it is possible to provide high levels of economic benefits while directing those benefits to the poor.

2. Number of Urban Households

6.24 The next issue to be examined concerns the distribution of benefits. Table XIV presents the estimated number of urban households benefitting from shelter and infrastructure improvements provided by urban projects.

TABLE XIV: ESTIMATED NUMBER OF HOUSEHOLDS SERVED BY SHELTER TYPE PROJECTS 1/

Fiscal Year	No. of Projects	Total No. of Households	Average
72 2/	1	15,600	15,600
73	1	6,400	6,400
74 3/	2	11,550	5,775
75	6	249,075	41,513
76	2	43,116	21,558
77	4	305,292	76,323
78 4/	11	408,001	37,091
79	6	257,069	36,724
80	9	161,050	17,894
81	7	432,510	61,787
Total	49	1,889,663	38,565

1/ Transport excluded.
2/ Turkey not included.
3/ No estimates for Calcutta I.
4/ Nicaragua not included.

The increase in the average number of households per project in FY81 reflects a growing concern with program impact within specific cities as suggested earlier in the case of Madras. A figure of 62,000 households represents some 300,000 persons which is equivalent to the population of a medium-sized city in most developing countries.

3. Percentage of Total Project Costs Providing Direct Benefits to the Urban Poor

6.25 Table XV classifies projects according to their share of benefits allocated to the urban poor. Seventy percent of all urban projects had high urban poverty content, defined as those projects having more than 40% of their total costs destined for the poor, defined according to urban poverty thresholds for individual countries.

TABLE XV: PERCENT OF TOTAL PROJECT COSTS WITH DIRECT BENEFITS TO THE URBAN POOR

	Total No. of Projects	Projects with UP Data	Urban Poverty Content (%) 10 - 20	20 - 40	40 - 60	60+
East Africa	10	10	-	1	2	7
West Africa	5	5	-	2	-	3
East Asia	15	10	4	1	1	4
South Asia	5	2	-	1	-	1
EMENA	7	5	1	2	-	2
LAC	18	15	-	2	4	9
	60	47				
Percent of all Urban Projects with poverty content in each category			11%	19%	15%	55%

6.26 These patterns are further clarified when the data are presented according to project type. These data show that both shelter and integrated projects are able to deliver substantial benefits to the target groups, while the transport projects have broader city-wide impacts which cannot as easily distinguish poor versus non-poor beneficiaries.

TABLE XVI: PERCENTAGE OF TOTAL PROJECT COSTS DIRECTED TO THE URBAN POOR BY PROJECT TYPE (FY73-81)

Project Type	Percentage of Project Costs 0-20	20-40	40-60	>60
Shelter	12.9	6.5	22.6	58.0
Transport	33.3	33.3	-	33.3
Integrated Projects	-	30.0	-	70.0
Regional Development	-	100.0	-	-
All Urban	10.9	17.4	15.2	56.5

Note: Total number of projects included in this sample is 46, distributed as follows:

Shelter	31
Transport	3
Integrated Projects	10
Regional Development	2

6.27 Taken together, these three measures of direct benefits show that urban projects provide substantial benefits to the participating populations. Projects are economically and financially justified while also meeting important distributional objectives in reaching the urban poor. While methodologies are not available to quantify secondary benefits through improved worker productivity, it is nonetheless apparent that better shelter, water supply, and sanitation are necessary conditions to maintain health and therefore productivity. In addition, numerous unmeasured benefits such as savings in foreign exchange, savings mobilized in the economy, and environmental improvements have also resulted from the projects.

F. Impact in the Development Assistance Community

6.28 A final type of impact which has resulted from the Bank's urban operations has been the gradual creation in the international aid community of a consensus on approaches to the urban sector. Despite the fact that the Bank's entry into the urban sector was different from the types of activities of agencies such as USAID, the Caisse Centrale de Cooperation Economique, the British ODA, and the United Nations, these agencies have shifted their activities towards the Bank approach, enriching it by their own experiences in the field of housing over the years. An example of this shift is the financing of sites and services and slum improvement by USAID, even some joint financing of projects such as the first Ivory Coast Urban Development Project, which is a departure from earlier USAID housing operations which mostly served the middle class. Similar patterns have occurred with the French assistance program, as subsidized middle class housing has given way to sites and services. Concepts such as affordability, replicability, low-cost design, and "urban" as distinct from "housing" projects, are now the central principles in urban lending of all key lending agencies. While this situation has led in some cases to a type of "competition" between the Bank and other agencies in countries where the government has asked both institutions for support in the urban sector, it is better that competition occurs over which agency will finance the project rather than which type of project will be financed.

6.29 The demonstration effects of Bank lending have also resulted in further activities, such as training courses sponsored jointly with the United Nations Centre for Human Settlements. Methodologies and results are discussed in detail in urban studies programs in universities in the United States, Britain, France, and the Netherlands, as well as many programs in developing countries. There are even cases of consultant firms deciding to build up their capacity to work on sites and services programs, realizing that the future in urban assistance lies in this direction. While this is just a partial list, it is nonetheless apparent that the scale of Bank urban activities has had a growing impact beyond project lending.

VII. CONCLUSIONS: THE TASK AHEAD

7.01 This retrospective review has described the evolution of urban operations over the past decade, relating objectives to performance and impact and in the process, identifying areas for improvement. While the conclusions of the review are necessarily of an interim nature, considerable achievements have already been identified. The theme of learning by doing has characterized the experience from the outset. A strategy of research and development has resulted in a range of significant impacts within the first decade of activity. At the same time, the strategy established the foundations for future expansion of urban lending. At the beginning of 1982, it is apparent that substantial momentum has been generated both within the Bank and within Borrower institutions. This concluding section will examine what is in the pipeline and the outstanding issues to be addressed in the medium term. Before turning to these subjects, it is important to restate prospects for urban growth in the 1980's.

A. Urban Growth in the 1980's

7.02 Despite the progress made in developing improved solutions for addressing problems in the urban sector, the magnitude of the challenge of urban growth has not diminished over the past decade. As the projections of the early 1970's indicated, urban populations have continued to grow in all countries of the world, even where rural development efforts have been effective and sustained. Higher energy costs and world-wide inflation have placed new strains on productivity, much of which continues to be generated in urban areas in developing countries. The need to maintain productivity is greater than ever, with supporting services and infrastructure essential for efficient urban economic activity. Such services are required in the metropolitan agglomerations as well as in the new secondary urban centers where much of the current growth is taking place. Greater demands for services emphasize the importance of increasing institutional capacity in the sector, whether in providing infrastructure, shelter, or maintaining and operating existing investments. Project experience has demonstrated that institutions remain the key to these efforts.

7.03 Evaluating world-wide trends in urban growth leads to the inevitable conclusion that urban development efforts will have to be redoubled over the next decade if the solutions developed during the 1970's are to be extended to growing populations. All regions of the world are experiencing the same process, although the patterns of growth and the capacity to respond vary significantly. The more urbanized regions such as Latin America and East Asia have recognized their problems and have actively sought Bank assistance in the sector. Despite large rural populations, South Asian countries also appreciate the needs and economic importance of their large cities. The Middle Eastern countries have long experienced urban problems and will continue to require assistance to develop more effective solutions. The least urbanized countries, in Africa, while faced with urgent problems of food, health, and education, expect a quadrupling of their urban populations by the year 2000, thus creating heavy demands where there is the least institutional capacity to respond. Despite differences in urban conditions and level of development, it is apparent that all regions share the same long-term prospects in the sector: continued growth in demand for services which are essential for productivity. Assisting governments to meet those demands, the Bank's original objective in urban lending, thus still remains valid for the 1980's.

B. The Urban Lending Program: FY82-86

7.04 Probably the most important indicators of the momentum of the urban lending program are the more than 90 projects which are under consideration and preparation in the FY82-86 lending program. While there is uncertainty concerning the outer years in the program, it is indicative of the interest of the countries and the Bank that the number of urban operations has increased from some 62 operations in ten years to more than 90 in the coming five years. The operations are proposed for about 50 countries, of which about 25 would be new urban borrowers, adding to the 44 countries for which projects had been approved by the end of FY81. About half of the program consists of repeater projects. The proposed program would amount to about US$4.0 billion in lending over the five-year period. Some 50% of the proposed operations involve loan/credit amounts less than US$50 million, with only about 15% larger than US$75 million. The average amount is about US$45 million. It should be noted that this indicative program will be affected by availability of Bank Group funds.

7.05 While it is difficult to describe the proposed content of these operations, particularly for the outer years, the following general observations can be made about the program:

(a) Bank-assisted urban operations have become significant parts of the urban development programs in the most highly-urbanized regions, particularly in Latin America and East Asia. Major Borrowers in this sector include Philippines, Korea, Thailand, Indonesia, Brazil, Mexico, and Colombia. In addition, countries which have large urban populations, such as India, Pakistan, Nigeria, and Egypt are also expanding their urban programs with Bank assistance.

(b) The majority of operations are expected to focus on strengthening institutions responsible for the provision of urban shelter and infrastructure, both through specific institutional development components and through implementation of progressively larger investment programs.

(c) Urban transport lending is expected to expand, particularly with free-standing projects in cities where urban shelter and infrastructure operations are already underway, and which face growing urban congestion and transportation problems.

(d) The extension of urban lending to about 25 new countries reflects the growing consensus that the urban sector is an integral part of development, even in countries where it may not have the highest priority. These operations are likely to be quite modest in their scope in terms of components and limited in scale of investment.

C. The Challenge of Replicability

7.06 Urban project experience has demonstrated that replicability means doing more than repeating on a large scale the same things done in the past. The translation of projects into on-going programs requires new ways of addressing constraints in institutional capacity, public sector finance, and trained manpower and other emerging sectoral issues. Similarly policy questions such as the division of labor between the public and private sectors, the importance of the housing market, the role of institutional finance, and the efficiency of urban management will have to be faced as cities triple in size and an additional billion residents are added to the urban population of developing countries in the next two decades. The approach of "learning by doing", which has characterized urban lending since 1972, will have to be supplemented by more applied research and development to provide information and approaches necessary for future lending. On-going research in such areas as housing finance, housing demand, national spatial strategy, and the role of employment location in regional development fit within this framework and are expected to provide valuable inputs into the design of future Bank projects and the policy advice provided to Borrowers.

7.07 In this context three specific aspects of replicability which are addressed in operations planned for the short term suggest in concrete terms the directions of future lending: the importance of housing markets, the role of institutional finance, and the efficiency of urban management and its links to productivity.

1. The Importance of Housing Markets

7.08 Analysis of urban shelter in developing countries has indicated convincingly that in the medium term the public sector is unlikely to be able to provide more than a small share of needed services. Most urban residents obtain housing without the direct involvement of public institutions. This trend will become more evident as total demand increases. Public intervention in the housing market has been relatively weak, benefiting a few, while the majority solve their housing problems through self-help, private finance, and construction. While Bank projects gave demonstrated low-cost technical solutions and sound financial principles, i.e. cost recovery, the weakness experienced in public institutions indicates a need for increased emphasis in future projects on encouraging housing markets to work more effectively. Improving understanding of these markets from both the macro- and micro-economic perspectives will be an important element in designing public sector interventions which use the comparative advantages of both public and private sectors. This approach is reflected in projects under preparation in all regions. Sectoral studies have provided a more detailed view of the housing markets and a guide for project design.

2. The Role of Institutional Finance

7.09 A second area affecting replicability is an institutional approach to urban development finance. As suggested earlier, projects in many countries are developing institutional frameworks which emphasize the role of national institutions in channeling financial resources to the sector, with the Bank playing the role of catalyst while providing technical assistance. Projects seek to strengthen local institutions so that they can perform the necessary functions of channeling finance in ways which will further stimulate private investment within projects. As these institutions increasingly finance infrastructure and leave responsibility for house construction to private households, they can create conditions in which local housing markets can work more efficiently than in the past. This direction is being followed in all of the six regions of Bank lending; while the speed of change is dictated by existing institutional constraints, upcoming projects will increasingly transform the Bank role from retailer to wholesaler in urban development finance.

3. Urban Management and Productivity

7.10 The importance of efficient urban management, a third aspect of replicability, is, of course, evident in all countries. However, the importance of the orderly provision of urban services as a prerequisite for productive urban economic activities is not fully appreciated. When infrastructure such as water, power, or roads are not in place, or are not operated and maintained adequately the costs of production and distribution increase quite substantially. Since continuing provision of these services is in turn dependent on municipal finance systems which generate sufficient revenue to finance operations, how much municipal services are organized and financed becomes a vital aspect of urban management. Upcoming projects in large metropolitan areas address these issues on a city-wide level, seeking to identify the critical improvements required to support urban efficiency and thereby maintain and improve productivity of economic activities.

7.11 The goal of replicability will require detailed understanding of these issues within specific countries and cities as a basis for policy and institutional reform. Action through investments and physical improvements will be a larger part of the response to the demand for services. However, experience with urban projects indicates that such action needs to be supported by thorough evaluation, testing, and improvements of the instruments available to improve mobilization and use of public and private resources if further advances are to be achieved. In 1972, given the lack of solutions to urban problems, this strategy of coupling learning with doing appeared sensible as the Bank entered a new sector of lending. In 1982, based on a decade of experience, the strategy is not only sensible, but offers increasingly promising prospects of success.

LIST OF URBAN PROJECTS - FY72-81

	Loan Amount	Credit Amount
FY72		
Turkey Urban Development		2.3
Senegal Sites & Services		8.0
FY73		
Nicaragua Earthquake Reconstruction		20.0
Malaysia Urban Transport I	16.0	
FY74		
Botswana, Francistown Urban Development		3.0
India, Calcutta Urban Development		35.0
Iran, Teheran Urban Transport	42.0	
Jamaica, Kingston Sites & Services	15.0	
Tunisia Urban & Public Transport	11.0	7.0
FY75		
Kenya, Nairobi Urban Development	8.0	8.0
Tanzania National Sites & Services		8.5
Zambia, Lusaka Sites & Services	20.0	
El Salvador Sites & Services	2.5	6.0
Indonesia Urban Development I	25.0	
Korea Regional Development I	15.0	
FY76		
Peru Sites & Services	21.6	
Malaysia Urban Transport II	26.0	
Philippines Urban I	32.0	
FY77		
Ivory Coast Urban Development	44.0	
El Salvador Urban / Sites & Services II	6.7	6.0
Indonesia Urban Development II	52.5	
India, Bombay Urban Transport	25.0	
India, Madras Urban		24.0

	Loan Amount	Credit Amount
FY78		
Bolivia Urban Development	17.0	
Botswana Urban Development II	8.0	
Brazil Urban Transport	88.0	
Colombia Urban Development I	24.8	
Costa Rica, San Jose Urban Transport	16.5	
Egypt Urban Development I		14.0
India, Calcutta Urban Development II		87.0
Kenya Urban Development II	25.0	25.0
Mexico Cardenas Conurbation	16.5	
Morocco Urban Development	18.0	
Tanzania National Sites & Services		12.0
Thailand, Bangkok Sites & Services	8.6	
Upper Volta Urban Development		8.2
FY79		
Mali Urban		12.0
Tunisia Urban Development	19.0	
Brazil Sites & Services	93.0	
Brazil Medium Cities Development	70.0	
Colombia, Cartagena Urban Development II	13.5	
Indonesia Urban Development III	54.0	
Philippines Urban II	32.0	
Thailand, Bangkok Traffic	16.0	
FY80		
Burundi Urban		15.0
Lesotho Urban I		6.0
Nigeria Urban Development, Phase I	17.8	
Ecuador, Guayaquil Urban Development I	31.0	
Nicaragua Urban Reconstruction		22.0
Panama Urban Development	35.0	
Korea, Gwangju Regional II	65.0	
Philippines Urban Development III	72.0	
Thailand National Sites & Services	29.0	
India, Calcutta Urban Transport		56.0

	Loan Amount	Credit Amount
FY81		
Brazil Urban Transport III	90.0	
Indonesia Urban Development IV	43.0	
Jordan Urban Development I	21.0	
Korea Urban Housing	90.0	
India, Madras Urban II		42.0
Mauritius Urban Rehabilitation	15.0	
Mexico Regional Development II	164.0	
Morocco Urban II	36.0	

Annex 2

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INTERNATIONAL BANK FOR
RECONSTRUCTION AND DEVELOPMENT

URBAN PROJECTS DIVISION

A REVIEW OF WASTE STABILISATION PONDS

FINAL DRAFT

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VOLUME I

MAIN REPORT

CONTENTS

1. INTRODUCTION

Terms of Reference

1.1 The Terms of Reference for the Stabilisation Pond Review were set out in an office memorandum from David Cook dated April 24th, 1981. The review was particularly concerned with design aspects, bidding and construction, and operation of the systems visited. The detailed Terms of Reference are shown in Annex A.

1.2 To those items listed in the Terms of Reference have been added the following:-

Design

Preliminary treatment method (if any)
Flow measuring devices (if any)
System bypass
Pond draw down facilities
Interpond connections
Inlet and outlet design
Planting for erosion control
Access

Operation

Operational efficiency
Actual loading rates
Problems with industrial wastewater (if any)

Itinerary

1.3 The travel itinerary and pond systems reviewed and visited at each location were as follows:-

May 12th - 15th	Manila, Philippines, review Dagat Dagatan pond system.
May 16th - 19th	Calcutta, India, review East Calcutta waste treatment and recycling system proposals.
May 20th - 31st	Israel, review pond systems at Ramat Hasharon, Bet Shemesh, Ramle and Naan, Lod, Or Yehuda, Netanya, Tel Mond, Sederot, Yavne, Ashdod, Einshemer, Migdal Maemeq, Nazareth, Karmiel, Shelomi, Kiriyat Gat, Ofaqim, Beer Sheva, Arad, Eilat.
June 1st - 4th	Nairobi, Kenya review Dandora waste stabilisation pond system and visit industrial estate pond system.

June 4th - 8th	Lusaka, Zambia, review Ngwerere waste stabilisation pond system and visit pond systems at Matero, Manchichi, Munali, Chelston.
June 9th - 18th	London, report writing.
June 18th - 20th	Washington, Submission of draft report.
June 20th - 24th	Kingston, Jamaica, review Spanish Town waste stabilisation pond system.

Acknowledgement

1.4 I would particularly like to thank David Cook for producing such a valuable and relevant Terms of Reference and Shaul Streit for his help and guidance in Israel.

1.5 Foremost amongst the many others to whom thanks are due are:-

Manila	Col. Antonio Fernando Eduardo Arguilles Rosalinde Sotelo
Calcutta	Mr A.C. Gangully Mr S.K. Roy Mr P.K. Dutta Mr S.K. Basu Mr M.K. Nag
Israel	Mr Meir Ben Meir
Nairobi	Mr Peter Karimi Mr Joe Nguigute
Lusaka	Mr P. Muyangwa Mr Leonard Sepiso Mr M.C.S. Raju Mr S.O. Mensa
Kingston	Mr A. Sailsman Mr F. Lyn Mr F. Rose Mr R. Foster

1.6 Finally, I would like to thank all those Bank staff and others who read and offered comments and suggestions on the first draft of this report. Wherever possible these have been incorporated into this final draft. However, time has not allowed incorporation of all the suggested improvements, and I would like to apologise to those whose comments and suggestions have not been included for lack of time.

2. FACTORS EFFECTING CHOICE IN SEWAGE TREATMENT

Conventional Treatment Plants

2.1 Almost all types of conventional sewage treatment processes were developed in the temperate or colder climates of Western Europe. Although night soil ponds have been in use for thousands of years they have never been appropriate for climates with a pronounced cold season as their successful operation is dependent on high ambient temperatures and a high level of solar insolation

availability of land

2.2 Consequently, the developed countries, in developing piped sewerage systems, concentrated on two alternative disposal techniques - discharge directly into the sea from coastal communities and the use of high technology mechanical treatment processes prior to discharge into rivers or streams from inland communities.

2.3 The primary objective of the treatment processes developed in Europe has been to reduce the organic loading of the sewage effluent to a level at which it places no increased demand for dissolved oxygen on the receiving watercourse. Thus effluent standards are only concerned with Biological Oxygen Demand (BOD) and suspended solids.

2.4 Conventional treatment plants do not however, provide any significant degree of pathogen removal unless ancillary processes such as chlorination are incorporated.

Waste Stabilisation Pond Systems

2.5 It has long been accepted that tropical and sub tropical climates provide an ideal environment for the natural treatment of sewage.

2.6 By detaining raw sewage in shallow ponds for, say, ten days or more, a significant level of both BOD and pathogen removal can be achieved. The natural action of warmth and sunlight promotes the rapid growth of microbiological organisms which consume BOD both aerobically by utilising photosynthetically produced oxygen, and anaerobically.

2.7 Alternative arrangements of pond sizes and depths can be used to promote either aerobic or anaerobic activity. The resultant effluent will be nutrient rich through its high algal content but will be low in pathogens and other faecal bacteria. This is particularly relevant in hot climates where the spread of gastroenteritic diseases by waterborne pathogens presents very serious problems particularly in densely developed urban areas.

Factors Effecting Choice

2.8 There can be little doubt that, if the main objectivesof sewage treatment are accepted to be pathogen removal followed by BOD removal then in hot climates waste stabilisation ponds must always be preferred to conventional mechanical treatment processes where adequate affordable land is available.

2.9 If capital cost is a primary consideration then again, subject only to land availability, pond systems will invariably represent the least cost solution.

2.10 It is however in the field of operation and maintenance that the most compelling case for ponds can be made. Well designed pond systems will continue to provide a high level of BOD and pathogen reduction even without regular maintenance. The recommended maintenance procedures, apart from effluent monitoring, can be undertaken by unskilled labour.

2.11 Conventional plants require a high level of technical competence from the operating and maintenance staff. Standard operating procedures are technically complex and any failure to carry them out will result in plant breakdown.

2.12 Thus operating and maintenance costs are cheaper, and operation less technically complex for pond systems than for conventional plants. Additionally, overloading can generally be accepted for periods up to one month by facultative pond systems before odour problems become apparent and effluent quality is effected. With conventional plants any overloading will immediately reduce effluent quality and may cause total system failure.

2.13 All conventional sewage treatment plants require regular sludge removal resulting in a demand for large areas of drying beds or for sophisticated and expensive sludge digestion facilities. A well designed system of facultative and aerobic ponds will frequently be able to function for over 20 years before sludge build-up reaches a level that requires removal.

2.14 The effluent from conventional plants is often unsuitable for agricultural re-use unless additional and costly effluent polishing processes are incorporated. If chlorination is used it may be relatively uneffective and the after effects may even be detrimental to crops.

2.15 The effluent from waste stabilisation ponds however, is rich in nutrients through its high algal content. These nutrients can be recovered by direct irrigation or by drying the algae to produce food for animals or for fertilizer, although simple methods of algal removal are yet to be developed. Alternatively, with careful design and good monitoring the tertiary and subsequent ponds can be used for aquaculture. Various fish, particularly carp and tilapia, thrive in the algal rich environment of these ponds and yields of up to 10 tonnes per hectare per year have been recorded.

2.16 Thus in warm climates, providing adequate land is available, the use of waste stabilisation ponds for the treatment of sewage effluent presents overwhelmingly the least cost most effective option. It is therefore surprising that many countries consider ponds an unacceptable alternative to conventional plants.

2.17 There are various reasons for this among the most important of which is that many of the major international lending agencies and most of their consultants are from the developed countries of the west where the climate has precluded the use of ponds or, where ponds are used, the climate necessitates very low loading rates, therefore, they are often seen as the second-best choice.

2.18 Many authorities and some consultants reject ponds on the grounds of odour nuisance and fly-breeding. In this respect, they are in reality often better than conventional plants. The simple maintenance function of breaking up algal mats and preventing vegetation from growing into the ponds will preclude the creation of the environment necessary for fly and mosquito breeding. In conventional plants the many areas of standing water from overflow or sludge removal areas and in pumping shafts can create ideal breeding conditions for flies and mosquitos.

2.19 With any level of maintenance below the optimum, a conventional plant will suffer from excessive sludge build up, and serious odour problems result. A well designed pond system, with only simple maintenance requirements, will remain odour free throughout its life, and although not to be encouraged, will often work quite satisfactorily with virtually no maintenance at all.

2.20 Where either anaerobic or facultative ponds are incorporated into a pond system as primary units and become overloaded they can, with careful design, be converted into aerated lagoons by the installation of mechanical aerators. Whilst this option may be considered as a possible safety valve it does create further difficulty for the responsible agency in terms of the increased cost and complexity of both plant operation and maintenance procedures.

2.21 Overloaded anaerobic or facultative ponds can cause odour problems, but these may be eliminated by:-

i) Providing mechanical aeration as outlined above.

ii) Recirculating effluent, either interpond or intrapond, usually in a ratio of about 1:1 i.e. recirculation rate equals sewage flow rate.

or iii) Making physical changes to the way in which the pond system operates to restablish loading rates consistent with satisfactory facultative or anaerobic operation. Odour may also be caused by floating algal mats on facultative ponds. This may be avoided by regular breaking up of these mats as they form, as part of the routine maintenance duties.

2.22 Objections to the use of ponds have occasionally been raised on the grounds of increased risk of bilharzia (schistosomiasis). In fact ponds do not provide an environment suitable for the snail host which prefers unpolluted waters. Furthermore, unlike areas of fresh water lakes, the ponds create few opportunities for human/water contact. Thus there is little or no opportunity for the conditions suitable for the transmission of this disease to be established.

2.23 Lastly, if burgeoning urban growth results in pressure to resite and develop the sewage treatment works, then the operation of closing down a pond system and replacing it with a pumping station and rising main to a new site is simple and expedient. The land area released can be used for continued urban development almost immediately. The cost of closing down and rebuilding a conventional plant is prohibitive. The land area released is considerably less than with ponds, and due to the expense of breaking out and removing the old concrete structures it is costlier to develop.

2.24 During the course of the review of pond systems it was established that clients, governments and local authority officials with some experience of operating pond systems were invariably favourably disposed towards them. Potential clients and officials with no experience of such systems almost invariably viewed them with scepticism and concern, fearing poor performance and odour problems.

2.25 The case for ponds in tropical and sub-tropical climates appears overwhelming. Perhaps it is only by assisting potential clients and their officials to visit operating waste stabilisation ponds in their own or other countries that this barrier can be broken. A selection of visits to some of the many non-operational conventional plants in developing countries might also be worthwhile.

3. SUMMARY OF CONCLUSIONS

General

3.1 Of the pond systems reviewed which were in operation the vast majority were working highly satisfactorily, and in the case of the Dandora system in Nairobi coping satisfactorily with more than 100% overloading.

3.2 The status of each of the systems visited and brief description is provided in Annex B. Annex C gives a detailed report on each of the pond systems in a format which follows that suggested in the Terms of Reference.

3.3 Table 3.1 lists the systems visited, giving the population served, net area and, where available, cost of the system. Some indication of the type of system is also provided.

3.4 Of the 30 pond systems visited,

- i) 8 included aerated lagoons
- ii) 8 incorporated anaerobic ponds
- iii) 14 comprised facultative and/or reservoirs or maturation ponds only

3.5 Tables 3.2, 3.3 and 3.4 show the net pond areas per capita, capital cost per capita, and capital cost per unit net pond area for aerated lagoon systems, systems including anaerobic units and those without anaerobic units respectively. Table 3.2 also shows the power intensity for the aerated lagoons in Watts per cubic meter of pond volume. The figures are based on design populations unless the design figure is not available in which case the actual population served is used.

3.6 These tables show:-

- i) A wide variation in the capital cost and area of pond per capita, reflecting the wide variety of design procedures used, as well as the economies of scale.
- ii) Savings in pond area per capita with inclusion of anaerobic ponds or aerated lagoons in the system.
- iii) A general increase in the capital cost per capita of the system with the inclusion of aeration equipment.

TABLE 3.1

Population Served, Areas and Costs of Pond Systems Visited

Location	Population Served		Net Pond Area, ha	Cost[+] US$M	Type of System[*]
	Design	Actual			
Dagat Dagatan	45,000	-	5.2	2.0	AL,M
Ramat HaSharon	50,000	31,000	4.0	0.54 (3	AL,M (1
Bet Shemesh	25,000	-	4.8	0.97	F,M
Ramle	50,000	41,500	3.2	-	F
xNaan	-	41,500	11.1	-	F,R
Lod	-	42,000	2.8	-	AL,M
Or Yehuda	67,000	47,000	2.2	-	An,F,M (2
Netanya	-	100,000	15.3	2.23	AL,M
Tel Mond	12,000	3,500	1.3	0.28	An,F,M
Sederot	18,000	9,000	2.4	0.42	An,F,R
Yavneh	16,000	12,500	2.2	0.67	AL
Ashdod	95,000	66,000	13.0	-	F
Einshemer	11,000	7,000	3.3	-	An,F
Migdal Haemeq	15,000	13,800	12.0	-	R
Nazaret Illit	-	47,000	9.2	-	F, R
Karmiel	-	13,000	4.2	-	An,R
Shelomi	7,200	2,600	5.5	0.91	AL,R (1
Kiriyat Gat	-	26,000	2.8	-	F
Ofaqim	15,000	12,500	5.8	0.44	An,F,M
Beer Sheva	140,000	110,000	13.4	-	An,F,M
Arad	20,000	12,500	5.4	0.33	An,F
Eilat	-	30,000	3.2	-	AL
Dandora	200,000	400,000	95.0	4.5	F,M
Dandora Industrial	-	32,000	9.5	-	F,M
Ngwerere	-	36,000	13.8	0.52	F,M
xManchichi	-	100,000	23	-	M
Matero	-	30,000	10.6	-	F,M
Chelston	-	20,000	2.7	-	F,M
Munali	-	20,000	5.0	-	F,M
Spanish Town	3,400	2,600	2.5	0.28	F,M (2
East Calcutta	100,000	-	12.0 (4	0.9	T,F

Notes:
- x Following pretreatment in other works
- \+ Costs brought to October 1980 prices
- * AL - Aerated lagoon
  - An - Anaerobic pond(s)
  - F - Facultative pond(s)
  - M - Maturation pond(s)
- (1 - Aerators not in use
- (2 - System not operational
- (3 - Cost for improvements only
- (4 - Area for proposed pond system
- R - Reservoir

TABLE 3.2

Costs per capita and per unit area, area per capita, and power intensity of aerated lagoon systems

Location	Net pond area per capita M^2/capita	Capital cost per capita US$/capita	Capital cost per unit area US$/$M^2$	Power intensity Watt/M^3	
Dagat Dagatan	1.2	44.4	38.5		2.7
Ramat HaSharon*	0.8	10.8	13.5	Primary Secondary	3.5 1.8
Bet Shemesh +	1.9	38.8	20.2		3.2
Lod	0.7	-	-	Primary Secondary	2.6 2.0
Netanya	1.5	22.3	14.6	Primary Secondary	3.3 1.4
Yavneh	1.4	41.9	30.5	Primary Secondary	2.7 1.1
Shelomi	7.6	126.4	16.5	Primary Secondary	6 2.4
Eilat	1.1	-	-	Primary Secondary	4.0 1.2

Note: * Rehabilitation of existing system only

\+ Operated as system of anaerobic, facultative and maturation ponds.

TABLE 3.3

Costs per capita and per unit area, and area per capita of anaerobic pond systems

Location	Net pond area per capita M^2/capita	Capital cost per capita US$/capita	Capital cost per unit area, US$/$M^2$
Or Yehuda *	0.3	-	-
Tel Mond	1.1	23.3	21.5
Sederot	1.3	26.3	17.5
Einshemer	3.0	-	-
Karmiel	3.2	-	-
Ofaqim	3.9	29.3	7.5
Beer Sheva	1.2	-	-
Arad	2.7	16.5	6.1

Note: * System not in operation

TABLE 3.4

Costs per capita and per unit area, and area per capita of facultative pond systems

Location	Net pond area per capita M^2/capita	Capital cost per capita US$/capita	Capital cost per unit area US$/$M^2$
Ramle	0.6	-	-
Naan *	2.2	-	-
Ashdod	2.0	-	-
Migdal Haemeq *	8.0	-	-
Nazaret Illit	2.0	-	-
Kiriyat Gat	1.1	-	-
Dandora	4.8	-	-
Dandora Industrial	3.0	-	-
Ngwerere	3.8	14.4	3.8
Manchichi	2.3	-	-
Matero	3.5	-	-
Chelston	1.4	-	-
Munali	2.5	-	-
Spanish Town	7.3	82.4	11.2

Note: * Most of the area of these systems is made up of irrigation reservoirs.

Design

3.7 As indicated by tables 3.1 to 3.4 the design methods used for the systems visited varied considerably. In many cases the pond designs were very conservative, leading to excessively large and expensive systems. This was often combined with over estimation of the sewage flow rate leading to problems during commissioning (e.g Spanish Town, Kingston, ponds over 1 year in operation and still not full; Ngewerere, Lusaka, ponds six months in operation and the secondary units still empty). Use of the design equations given in the practical guidelines below would have resulted in considerable savings in land used, earthworks, and hence cost of the system.

3.8 Of those systems visited which had several pond units, the pipework required to allow flexibility of operation was often not present. Bypass pipes and facilities for drain down of ponds were also often not included.

3.9 Where a hard edge detail at the water surface level was not used in ponds, embankments were frequently suffering from erosion problems. This was found to be particularly true in aerated lagoons where the aeraters induced greater wave action.

3.10 Many of the systems visited were designed without either preliminary treatment for the removal or breaking up of large solids, or flow measuring devices.

3.11 With the exception of eight of the systems visited in Israel, anaerobic ponds had not been incorporated in the pond systems investigated. In many cases the option of using anaerobic ponds had either not been considered or had been rejected on grounds of odour or nuisance. In none of the systems visited where the feasibility study was available had a pond system including anaerobic ponds been considered in least cost solution analysis.

3.12 In aerated lagoons the positioning of the aerators often left dead areas at pond corners where sludge settlement and scum accumulation caused problems.

Construction

3.13 Problems were sometimes encountered during construction due to difficulty of operating earthmoving equipment during the rainy reason, or where the water table was high. Where change orders were required, most related to earthworks.

3.14 It has been found in Israel (1) that calculations of the quantity of earth moving required in pond construction are sometimes in error. Furthermore, particular problems were encountered by contractors in drawing up estimates for pond cleaning. Estimates of the quantity of material to be removed were often inaccurate, and problems were experienced in using heavy machinery to move the sludge before it was fully dried throughout its depth.

Reasons

Operation and Maintenance

3.15 Of those systems visited which would not be considered to be operating in a completely satisfactory manner, the problems generally related to parts of the systems other than the ponds themselves. The exceptions to this were some of the systems visited in Israel where considerable overloading or very poor maintenance was causing odour nuisance or poor effluent quality.

3.16 With well maintained and operated systems client and user reaction was highly favourable. In Lusaka, housing plots adjacent to an existing pond system have been taken in preference to those further away.

3.17 Clients and Government or Local Authority officials with some experience of pond systems were invariably favourably disposed towards them. Potential clients and Government or Local Authority officials without any experience of pond systems were invariably unfavourably disposed towards them, fearing poor performance and odour problems.

3.18 Maintenance costs for the systems visited were often not available. Where costs were available they varied considerably as shown in table 3.5 which gives the operating costs per capita served. As can be seen from this table, the cost per capita of operating an aerated lagoon system is generally almost an order of magnitude greater than the cost of operating a waste stabilisation pond system.

3.19 Many of the systems visited suffered from poor maintenance, generally in the form of:-

i) Failure to remove vegetation from embankments at water level.

ii) Failure to repair badly eroded embankments.

iii) Failure to remove scum from facultative ponds.

TABLE 3.5

Operating costs for pond systems where costs were available

Location	Total operating cost US$ for 1981 (predicted)	Operating cost per capita served per annum US$	Type of system *
Dagat Dagatan	92,300	2.05	AL
Netanya	260,000	2.60	AL
Yavneh	100,000	6.30	AL
Eilat	40,000	1.33	AL
Dandora	5,200	0.03	P
Ngwerere	9,000	0.25	P
Manchichi	11,000	0.11	P
Matero	9,000	0.30	P
Chelston	3,500	0.18	P
Munali	2,300	0.12	P
Spanish Town	5,500	1.61	P

Note: * AL - Aerated Lagoon System
P - Waste stabilisation pond system

At Ramat HaSharon the income from sale of the effluent for irrigation of citrus orchards is greater than the expenditure on operation and maintenance.

iv) Failure to prevent sludge build up around inlet pipes from penetrating the water surface.

v) Failure to keep grass cut on embankments.

vi) Failure to repair and maintain boundary fencing.

These maintenance problems are in the case of (i), (ii), and (iv) caused in part by poor design.

3.20 Industrial effluents caused problems in some of the pond systems visited but appeared to cause no problems in others. In some cases insufficient attention had been given at the design stage to the nature of the industrial effluent to be treated.

Performance and Monitoring

3.21 At very few of the systems visited was any kind of regular monitoring of flow rates, or raw sewage and effluent biological and chemical parameters carried out. In cities where both conventional and waste stabilisation pond sewage treatment plants were located, the laboratory, laboratory staff, and usually over 90% of the samples taken, were restricted to conventional plants. At only one of the systems visited (Netanya in Israel) was there an operating laboratory at the pond site, although Dagat Dagatan had both laboratory and equipment but nothing to measure!

3.22 Where flow measuring devices had been included in construction, these were often of the venturi flume type, and were invariably broken.

3.23 Standards were often not specified for effluents from the systems visited, and when they were, tended to be the Royal Commission standard of 20mg/l BOD_5 (5 day biochemical oxygen demand) and 30mg/l S.S. (suspended solids). Effluents from many of the pond systems were rich in algae and consequently unlikely to satisfy the Royal Commission standard. Although the algae can cause a problem where pond effluents are disposed of to a watercourse, they are an advantage where complete disposal is achieved by use of the effluent for irrigation. Improved crop yields invariably result from irrigation with pond effluent, although only in Israel was the effluent being reused in this way.

Israeli 'Kibbutz' System

3.24 This system, which was being operated at a number of the pond locations visited in Israel, usually functions in one of two ways:-

i) Kibbutz operates and maintains municipal wastewater treatment plant in exchange for use of the effluent for irrigation.

ii) Kibbutz uses effluent from municipally owned and operated treatment plant, either free of charge or for payment.

Usually the land on which the treatment plant (invariably a waste stabilisation pond system) is constructed by the municipality is owned by the kibbutz. The kibbutz is prepared to give up this land in exchange for the increased crop yields achieved by use of the effluent. Whenever these arrangements are made the approval of the Water Commissioner for the system has to be sought.

3.25 The system works particularly well because both parties are satisfied. The municipality finds land at some distance from the community to construct a treatment plant thus getting rid of the sewage without having a treatment plant on their doorstep. The kibbutz is happy to give up the land in exchange for the increased crop yields obtained by irrigating with the effluent. By operating the system themselves they are also able to organise it in such a way as to satisfy their water management requirements.

3.26 Effluent standards are very seldom specified nor are effluent analyses carried out, since the vast majority of irrigation in Israel is of nonedible crops such as cotton, sunflowers, alfalfa and other fodder crops. Permission to irrigate edible crops with a particular effluent must be obtained from the Ministry of Health. There are no official effluent standards relating effluent quality to crops irrigated or to stream discharge. Matters relating to effluent requirements for irrigation are dealt with by consultation between the Ministries of Health and Agriculture. Although these ministries do fix effluent standards, they appear not to have the means to monitor the effluent quality on a regular basis.

3.27 The problems with this system which limit its application to other locations are:

i) The lack of statutory effluent standards, which is seldom the case in other countries.

ii) The more sophisticated agricultural methods employed in Israel than in most developing countries.

iii) The social attitude to use of effluents for irrigation, often sensitive in developing countries.

iv) The types of crop grown.

3.28 From the point of view of pond operation, many examples were found of ponds being used in slightly unorthodox ways in order to maximise effluent reuse. Thus systems were often not being used in the way in which they were intended to be used, and doubtless treatment efficiency was suffering accordingly. It was also often the case that routine maintenance was badly neglected particularly during the irrigation season. This sometimes resulted in malfunctioning systems with scum and vegetation growth problems and in some cases odour nuisance.

3.29 All the systems visited in Israel were situated outside, or on the periphery of, towns or small cities. The type of effluent reuse system operated under these circumstances would not be possible in large urban conurbations where pond systems are situated within the built up area of the city.

4. RECOMMENDATIONS

Client Familiarisation

4.1 Where a Waste Stabilisation Pond System is being considered for sewage treatment it may be advantageous to show the client an efficient existing pond system if possible. This will serve to allay any fears based on rumours of poor quality effluent and odour problems. Where the clients are reluctant to accept ponds in preference to more conventional treatment systems, a visit to one of the many malfunctioning conventional plants in developing countries might also prove of value.

Design

4.2 When pond systems designed by consultants are reviewed, the design criteria should be carefully considered and compared to rational design procedures outlined in recent technical literature. Those documents which were available outlining design methods used for the pond systems visited, suggested a general tendency for consultants to use very conservative design procedures. Furthermore, where a least cost solution was sought, the option including primary treatment by anaerobic ponds was either not considered or excluded for reasons of odour or fly nuisance.

4.3 Although recent work (2) has shown that inclusion of anaerobic ponds may not necessarily lead to the minimum cost solution, considerable land use and construction cost savings can usually be made by the inclusion of anaerobic ponds in a system.

4.4 Fears of odour and fly nuisance are unfounded if the anaerobic units are properly designed and maintained. The design methods are outlined in the guidelines below. A properly functioning pond will have a thick crust over the entire surface, and of the systems visited a good example of a satisfactorily operating anaerobic pond was at Sederot, Israel. The pond was odour and fly free and operating with the following characteristics:

Detention time	3.3 days
Areal loading rate	2,150kg BOD_5/ha/day
Volumetric loading rate	0.11kg BOD_5/m^3/day

The depth of 1.85m is rather shallow and increases the frequency with which the anaerobic ponds require de-sludging. One pond was being de-sludged at the time of the visit.

At Beer Sheva the pond operation had been changed shortly before the visit in an effort to reduce an odour and fly nuisance problem and improve effluent quality. An increase in the volumetric loading rate from 0.54 kg BOD_5/m^3/day to 0.108 kg BOD_5/m^3/day, and in the areal loading rate from 1,212 to 2,425 kg BOD_5/ha/day on the primary units had caused some improvement according to the pond operator.

4.5 Where anaerobic ponds are incorporated into a pond system the minimum number of units required is two. These should be able to operate in parallel so that anaerobic treatment can continue whilst each pond in turn undergoes periodic sludge removal. An alternative arrangement is to have 3 anaerobic units each of which can operate in parallel or series. Two of these units can be operated in series whilst the third is being cleaned. Use of two anaerobic units in series has been found to provide good treatment(3). Where a facultative pond forms the primary unit of a series it is also necessary to provide either a parallel unit or the facilities to allow the raw sewage to bypass the primary pond and enter the secondary pond to allow sludge removal from the primary.

4.6 Nervousness on the part of the client with respect to use of anaerobic ponds can be overcome by the provision of aerators as an 'insurance policy' (example Bet Shemesh). Aerators can be used to control odour problems resulting from overloading of either anaerobic or facultative ponds. Where shallow ponds require aeration a large number of low powered aerators can be used. Recirculation can also be used to overcome nuisance problems resulting from overloading. Both systems work on the same principle which is providing oxygen to the surface layers of the pond thus oxidising gasses as they pass through this layer. Both these alternatives result in additional maintenance problems and operational costs.

4.7 Anaerobic ponds may be converted to aerated lagoons by the addition of aerators. This can probably best be carried out by designing the anaerobic lagoons sufficiently deep (>3m) and constructing the parallel units adjacent to each other so that the central embankment could be removed to give a single larger unit. Adding aerators to the ponds without making structural changes would result in very low detention times in the aerated lagoons (say 2 days instead of the optimum 4 days), resulting in lower treatment efficiency.

4.8 Care should be taken in the siting of aerators to avoid dead areas in aerated lagoons where solids are able to settle out in the quiescent conditions. This can cause sludge banks to form with the associated nuisance problems. More small aerators rather than fewer large ones provide more evenly spread mixing, and rounded pond corners are also a help in avoiding dead areas.

4.9 For the larger pond systems in particular, say, flowrate > 5,000 m^3/day, interconnecting pipework should be provided to allow maximum flexibility of operation. The pipework should ideally allow units to be operated in series or parallel and permit continuity of operation with one pond removed from service for cleaning. A bypass which serves each unit is also useful, and may be combined with drain down facilities which can be provided for each pond. However, a bypass for the whole system may provide an opportunity for the operator to avoid treating the waste at all when operational problems arise. Consequently it may be prudent to provide bypass and drain down facilities for anaerobic ponds and primary facultative ponds only, since these are the only units likely to require regular cleaning during the lifetime of the system.

4.10 Wherever industrial effluents are included in the sewage to be treated by a pond system, information should be sought on the nature of the effluents involved. Particular attention should be paid to this aspect when the proportion of industrial effluent is greater than about 20% of the total sewage flow. There are basically three types of effluent which can cause particular problems with a pond treatment system:

i) Effluents containing a high proportion of phenol based hydrocarbons will cause inhibition of algal photosynthesis, and should not be allowed to discharge into pond systems.

ii) Effluents with a nutrient balance which differs widely from that of domestic sewage may cause reduced treatment efficiency, or algal inhibition and hence increased risk of anaerobicity in facultative ponds. Some form of pre-treatment may be required, or the nutrient balance may be artificially restored by addition of other chemical or organic waste.

iii) Effluents with a very high organic content may require pretreatment in an anaerobic pond before discharge to the main pond system.

In spite of the potential problems, the reservoir effect of pond systems makes them the ideal treatment method to cater for shock loadings.

4.11 Maintenance problems can be minimised at the design stage by ensuring:

i) Inlet designs which give good inflow distribution to avoid sludge and grit settlement and accumulation near inlet pipe. Alternatively, a deep sump may be constructed near the inlet to hold grit if grit channels are not provided in pretreatment. Best distribution of inflow is achieved by use of multiple inlet pipes.

ii) Outlets which can draw off from various depths, or at least surface outlets provided with scum guards.

iii) Embankments with a hard edge detail at the water surface level.

iv) Embankments with a side slope not greater than 3:1 to avoid embankment erosion, (unless the soil is very stable and can be very highly compacted).

v) Anaerobic ponds should be provided with a pitched access ramp if vehicular removal is to be used. In systems with very large ponds (say, > 2 ha each) a paved area of embankment to enable a small boat to be launched should be included.

4.12 Flow measuring devices should be provided at the inlet to and outlet from a pond system. For pond facilities without permanent technical staff at the plant, a V notch is the best method. Where technical staff are able to provide regular maintenance of the equipment, venturi flumes may be used. The inlet flow measuring device should be placed after any pretreatment to avoid blockage or damage from large solids.

Maintenance and Operation

4.13 Maintenance labourers should be given clear instructions on their duties and the frequency at which these should be carried out. Maintenance manuals are advisable either written or, in the case of illiterate staff, explained by illustration. Maintenance duties will generally comprise:-

i) Grass and other vegetation cutting.

ii) Scum removal.

iii) Embankment maintenance.

iv) Fence and lighting repair (where applicable)

v) Checking on inlets, outlets and interpond connections.

vi) Duties related to method of pretreatment (screen cleaning and burial of screenings), flow measurement or pond monitoring etc.

vii) Spraying for mosquito and fly control and for control of vegetation (where applicable).

4.14 The operational staff requirement for a pond system depends on the following:-

i) Size of the system.

ii) Method of preliminary treatment employed.

iii) Existance of a laboratory on site.

iv) Nature of the labour market viz a viz rates of pay for labourers.

v) Availability of mechanical maintenance equipment (e.g. lawn mowers).

vi) Existence of ancillary facilities.

4.15 The diversity in number of staff employed at each facility is best demonstrated by example.

i) Beer Sheva, Israel, treating 16,000 m^3/day in 16ha of ponds -1 part time operator. Population served: 110,000.

ii) Dandora, Nairobi, treating approx. 60,000m^3/day in 95ha of ponds - approx. 40 full time staff. Population served 350,000.

4.16 Because of the factors mentioned in paragraph 4.14 above, it is difficult to provide recommendations for staffing levels at pond systems of various sizes. However, based on observations of satisfactorily maintained systems and assuming that the system is located in a developing country with a typically cheap labour market, some suggested staffing levels are presented below.

Population Served	10,000	25,000	50,000	100,000	250,000
Foreman/supervisor	-	-	1	1	1
Mechanical Engineer [1]	-	-	-	1	1
Laboratory technician [2]	-	1	1	1	2
Assistant foreman	-	1	2	2	2
Labourers	1	2	4	6	10
Driver [3]	-	-	1	1	2
Watchman [4]	1	1	1	3	5
TOTAL	2	4	9	15	23

Note:
1 Dependent upon amount of mechanical equipment used
2 Dependent upon existence of laboratory facilities
3 Dependent upon use of vehicle towed lawn mowers etc.
4 Dependent upon location and amount of equipment used

Construction

4.17 Soil sampling and analysis should be carried out at the proposed site as part of the design process. A thorough investigation of the site will avoid the delay and expense which can be caused when problems are discovered after initial construction (for example the percolation problems found at the Shelomi system, necessitating lining of system after construction).

4.18 The programme of works should be drawn up so that wherever possible the need for heavy earth moving equipment to be used on site is restricted to the dry season. The attention of contractors should be drawn to possible problems of using heavy earth moving equipment in areas to be excavated to levels only just above the water table. Particular attention should be paid to the careful checking of calculations for the earthworks required, to avoid cost overruns on this item.

4.19 Pond cleaning should be undertaken when the pond is approximately half full of sludge, although the liquid depth should not be allowed to reduce to less than 1m in facultative ponds. This will generally occur every two years with an anaerobic pond, or every ten to twenty years for a primary facultative pond. In the case of anaerobic ponds this could mean up to 2m depth of sludge, whereas for facultative ponds the depth will generally be less than 1m. Estimation of the quantity of sludge to be removed has been found to cause problems for contractors in Israel. A solids content of about 25% can be expected after drying, although sludge bulking might mean a volume of dry sludge equal to about 50% of the volume of wet sludge.

4.20 Sludge removal can be carried out by raft mounted sludge pumps or by manual removal and carting away, which appears to be a more common method. The main problems appear to be provision of sludge drying beds in the case of the first option and achieving complete sludge drying in the case of the second.

i) Raft mounted sludge pumps are probably a preferable alternative where, a) there is a short dry season limiting sludge drying time; or b) the sludge is very deep. One advantage is that the pond can quickly be returned to normal use once the sludge has been pumped out. The main disadvantage is the need for sludge drying beds. (assuming sludge accumulation of 0.04 m^3/capita/yr and pond desludging every two years, about 0.5m^2 per capita of drying bed would be required).

ii) Sludge drying in situ is probably a preferable alternative where,

a) There is a long dry season.

b) The sludge layer is not too deep (say 1m or less)

Problems may still be encountered with the surface of the sludge drying to form a crust, whilst the sub surface layers remain wet. Once the sludge has dried throughout its depth it should be bulldozed or excavated to one side. If there is a market for the sludge, local farmers should be encouraged to come and collect it themselves, otherwise it will have to be carted away. To facilitate this, ramps should be constructed to ponds which are likely to require frequent desludging by this method. Otherwise the embankment will have to be removed or flattened to allow access, and carefully reinstated after use.

Treatment Monitoring and Effluent Standards

4.21 Regular monitoring of flow rates and influent and effluent quality is desirable at all treatment plants, since it allows:-

i) Monitoring of effluent quality.
ii) Measurement of water losses.
iii) Calculation of hydraulic and organic loading rates, enabling impending overloading of the system to be predicted and possibly avoided.

At most plants laboratory facilities will not be included and hence regular monitoring will not be possible. However, if feasible, arrangements should be made for occasional sampling and analysis at an outside laboratory such as one serving another treatment system or a university. Where laboratory facilities are included at the pond system, regular sampling and analysis should be carried out using 24 hour composite samples.

4.22 Monitoring of faecal bacterial concentrations which is seldom undertaken at present should be included in all pond monitoring programmes. The indicator organisms Faecal Coliforms (similar to E. Coli but including additional strains (4)), and/or Faecal Streptococci should be used in preference to the non- exclusively faecal total Coliform group. The best method for determining bacterial concentrations in water samples is the membrane filtration method - see footnote.

4.23 Effluent standards based on the Royal Commission 20 mg/l BOD_5 and 30 mg/l S.S. standards are inappropriate for waste stabilisation ponds. This is because:-

i) The BOD_5 and S.S. of the effluent depend on the algal concentration, and are not a measure of the degree to which the sewage has been treated.

ii) Where discharge is into a river or watercourse, water from which is likely to be reused for domestic purposes downstream, a standard that includes bacteriological parameters is more appropriate.

4.24 Where the Royal Commission Standard is applied, problems can be encountered producing a waste stabilisation pond effluent to satisfy this standard because of the high algal concentration However, with a multi-cell series, the algal concentration in the effluent from the final pond is likely to have a sufficiently low algal concentration for the BOD_5 and S.S. to be relatively unaffected (5).

Footnote: The membrane filtration method involves filtering a given volume of sample (which may be diluted using standard serial dilution techniques) through a plastic membrane filter which has a pore size that causes bacteria to be retained on the filter. The filter is then placed on a pad or agar containing a selective media for the particular bacteria required, and incubated at the temperature and for the period required (e.g. Faecal Coliforms - 24 hours at 44.5^{o}C on M.F.C. Broth, Faecal Streptococci - 48 hours at 35^{o}C on M. Enterococcus Agar). After incubation the colonies can easily be counted on the squared filter paper to give the bacterial concentration per unit volume of filtered sample.

4.25 Wherever possible waste stabilisation pond effluents should be used for irrigation. This firstly makes a valuable contribution to nutrient recycling, providing increased crop yields, and secondly can allow effluent quality to be geared to the reuse method instead of having to satisfy statutory discharge standards, which may be irrelevant anyway (e.g. Royal Commission Standard).
The pond system may be designed to achieve the bacteriological standard required for the type of irrigation being undertaken which will depend on:

i) The crop being irrigated (i.e. inedible, low quality; edible, high quality effluent).

ii) The method of application (i.e. spray irrigation higher quality than drip or channel irrigation).

iii) Whether mechanically or manually intensive methods of agriculture are employed.

iv) Proximity to residential areas.

Recommended standards for irrigation of various types of crop by various methods of application are given in the Design Guidelines below.

Ancillary Use and Effluent Reuse

4.26 Although no facilities were visited where fish farming was being carried out on a commerical basis, many of the systems contained fish which local people occasionally removed for their own use or to sell (e.g. Manchichi, Zambia). In some systems the fish had migrated to the primary pond in the system where critical dissolved oxygen levels at night meant many of them did not survive. Fish farming in waste stabilisation ponds is undoubtedly a viable proposition, but should only be carried out in maturation ponds where dissolved oxygen is present throughout 24 hours.
Carefully managed fish farming in waste stabilisation ponds has provided up to 10 tonnes of fish per hectare per year(6). The most widely used species are tilapia and carp, or a polyculture of a variety of species. Where fish farming is carried out in waste stabilisation ponds, a fresh water depuration pond is advisable in which fish are retained before sale for consumption.

4.27 Direct algal harvesting from ponds was not practised at any of the systems visited. Simple and cheap methods of algal removal from pond effluents have yet to be developed (7).

4.28 The possibilities for the reuse of effluent for irrigation are considerable, and with the exception of Israel, potentially valuable waste stabilisation pond effluents from all the other systems visited were not being reused. Where effluent is to be used for irrigation of a particular crop, the pond system can be designed to achieve the required standard of effluent and to produce the required quantities of water at the right time of year. A good example of this is the irrigation of cotton in Israel where a large volume of water is required from June to August, and the quality is not particularly important since the crop is not eaten and mechanically intensive irrigation and farming methods are used. Thus large reservoirs are constructed, designed to be full at the beginning of the irrigation season and empty at the end.

4.29 Careful choice of the crops to be irrigated can maximise the reuse potential of the pond effluent. A good example is Beer Sheva in Israel with a winter crop (wheat), a summer crop (cotton), and a buffer crop (alfa alfa).

5. PRACTICAL GUIDELINES FOR FIELD USE

Introduction

5.1 There follows below a series of brief practical guidelines on the use, design and operation of waste stabilisation pond systems. These guidelines are based on observations from the pond systems visited on the study, and previous experience of the design and operation of waste stabilisation ponds.

5.2 These guidelines should enable pond system designs and cost estimates to be reviewed in the field, and give a rough idea of possible pond system alternatives. They are for the purpose of reviewing preliminary design or feasibility and planning, and are not a substitute for detailed design which should follow after a more thorough analysis.

Background

5.3 Domestic sewage comprises mainly faeces, urine and sullage, and is approximately 99.9% water and 0.1% solids. These solids are about 70% organic (mainly proteins, carbohydrates and fats) and about 30% inorganic (mainly grit, salts and metals). The large number of chemicals present in sewage makes it impossible to list them all, which is why sewage is generally characterised using other parameters. Industrial and commerical wastes will generally differ from domestic wastes in the proportion of organic material and inorganic salts present in the sewage. This may take the form of high organic content or a high proportion of salts. The high organic content may be readily bio-degradable (such as slaughterhouse or milk processing waste) or may not be readily bacterially degraded (such as textile industry waste). The organic and inorganic strength of sewage will depend on water supply, a low water consumption will result in a 'stronger' sewage.

5.4 The organic strength of sewage is normally expressed in terms of the oxygen demand exerted by the waste matter in undergoing complete oxidation. The most commonly used parameters are Chemical Oxygen Demand (C.O.D., where wastes are oxidised chemically), and Biochemical Oxygen Demand (B.O.D., where the wastes are biologically oxidised through bacterial degradation). The oxygen demand after 5 days of biodegradation is the parameter most commonly used (BOD_5) since this can be measured in a reasonably short period of time and generally has a fairly consistent relationship with the ultimate biochemical oxygen demand (BOD_{ult}). The BOD_5 contribution per capita

.17#/cap/day

can vary from around 25 grammes/day in African developing countries to about 80 grammes/day in the USA and Western Europe. These figures include sullage which has a far greater impact than dietary variations on the BOD_5 of the sewage. In fact the quantity of faeces produced per capita in developing countries tends to be greater than that produced in the developed world in net weight terms (averaging 150g as opposed to about 400g). However, due to the higher protein diet of the Western countries the BOD_5 produced per capita per day due to excreta is about the same. A typical design figure for an urban area in a developing country would be 40 to 50g BOD_5/capita/day. It is not possible to give typical allowance for industrial and commercial contributions. Where these are large they should be treated separately and individually, where small they may be considered as part of the domestic sewage flow.

5.5 Other commonly used parameters are suspended solids (S.S.) and Faecal Coliforms (F.C.). The suspended solids are the discrete particles present in suspension in the sewage or effluent and are responsible for turbidity. The Faecal Coliforms are a group of bacteria which are exclusively faecal in origin, the most common of which is <u>Eschericia Coli</u> (4). This group is used as an indicator organism for pathogenic bacteria (e.g. <u>Salmonella Typhi</u> and other gastroenteric bacteria) since the die off rates are similar.

5.6 The total organic load produced by a community can be estimated from the number of people served, a knowledge of the probable per capita BOD_5 production, and the contribution from industrial and commercial establishments. Where there is no major industrial contributor, the BOD_5 load from industry may be incorporated into the figure for domestic production by considering industry in terms of so many population equivalents. Where contributions from industry are large, they should be considered separately in calculating the total organic loading on the system. Although it is dangerous to generalise in view of the wide variations which can be expected with differing social customs, religion etc., a BOD_5 contribution per capita of 40 grammes/day with a wastewater contribution of about 100 litres/capita/day is probably reasonable. Assuming sewers are reasonably well constructed so that infiltration is kept down to about 15% of wastewater flow, this gives a raw sewage with a BOD_5 of 350 mg/l. There is likely to be some increase in per capita BOD_5 contribution with an increasing size of community due to higher income levels, although the size of community served may not reflect the size of the town or city itself. Approximate probable BOD_5 loadings from communities of various sizes are tabulated below.

Population Equivalent	BOD_5 load - Kg BOD_5/day
10,000	300
25,000	1,000
50,000	2,000
100,000	4,400
250,000	11,750

5.7 Organic matter, expressed as BOD_5 concentration, is normally stabilised biologically in sewage treatment. Thus BOD_5 is removed either,

i) aerobically (i.e. in the presence of oxygen) which can be represented simply by the formulae,

organic matter + oxygen $\xrightarrow{\text{bacteria}}$ new bacterial cells + NH_3, CO_2, H_2O.

ii) anaerobically (i.e. in the absence of oxygen) represented simply by,

organic mater $\xrightarrow{\text{bacteria}}$ new bacterial cells + alcohols, acids

followed by a second stage which simply represented is,

alcohols, acids $\xrightarrow{\text{bacteria}}$ new bacterial cells + CH_4 ? Ch_2, NH_3, H_2S, CO_2, H_2O.

The oxygen for aerobic oxidation may be provided mechanically, from diffused air or via algal photosynthesis, expressed simply by the formula,

CO_2, H_2O + algae $\xrightarrow{\text{light}}$ new algal cells + H_2O, O_2.

Both the aerobic and anaerobic bacterial oxidation processes are highly temperature dependent, increasing logrithmically with a linear increase in temperature.

5.8 Suspended solids can be reduced by settlement under quiescent conditions or by filtration. The finer suspended particles will settle out only after flocculation and coagulation. Where a very high algal concentration causes an effluent discharge problem, coagulation and subsequent settlement are the simplest solution, although further retention of the effluent will also reduce algal concentration as nutrient starvation occurs. Other methods can be used but these tend to be mechanically intensive and thus expensive.

5.9 Faecal bacteria and hence pathogenic bacteria are removed by starvation and the other effects of a hostile environment. Thus detention time is the key factor although other factors such as temperature ultra violet radiation and algal concentration also play a part. Most recent research on the subject (8) suggests that bacterial removal rate is mainly dependent on temperature and algal concentration, increases in both of which, increase the faecal bacterial removal rate. Virus die off appears to be effected more by the level of ultra violet light than faecal bacterial die off.

parasites?

Effluent Standards

5.10 The Royal Commission Standard of 20mg/l BOD_5 and 30mg/l.S.S., and other effluent standards based on these parameters are generally inappropriate in developing countries. High algal concentrations in effluents may contribute significantly to the BOD_5 and S.S. concentrations, and furthermore standards based on faecal bacterial concentrations are more appropriate for effluents which are either discharged to streams or reused for irrigation.

5.11 Various standards are recommended for effluents which are utilised for the irrigation of crops or are discharged to receiving streams (9,10,11, 12,13). All these are considered in the production of the effluent standard recommendations given below (Table 5.1) although other factors should also be borne in mind, including:

i) Method of application.

ii) Use of labour intensive agricultural methods.

iii) Proximity to residential areas.

5.12 The area of land which may be irrigated with a given volume of effluent is clearly dependent on climate, soil type and crop, as well as method of application. If an efficient irrigation system is operated, between 25 and 50 hectares of land can be irrigated on 1,000cu.m of effluent per day, which might be produced from a pond system serving a population of 10 to 15 thousand.

5.13 There are no effluent or pond standards relating to pisciculture in ponds. The limiting factor is usually the existance of some dissolved oxygen in the pond throughout the day and night, which will generally only occur in secondary, tertiary and

TABLE 5.1

Recommended Irrigation and Discharge Standards

Method of Reuse	BOD5 mg/L	Algal conc.+ cells/ml	Faecel Coliforms* nos./100ml
Irrigation of trees and non edible crops	60	-	50,000
Irrigation of citrus fruit trees, fodder crops & nuts	45	-	10,000
Irrigiation of deciduous x fruit trees, cooked vegetables, and sports fields	35	-	1,000
Discharge to a receiving stream	25	10^5	5,000
Unrestricted crop irrigation including parks and lawns	25	-	100

\+ The permissible algal cell concentration depends on the crop being irrigated, type of soil and method of application.

* These figures should represent the 80% confidence limit for Faecal Coliform concentrations.

x Irrigation should stop 2 weeks before picking and no fruit should be picked from the ground.

subsequent units in a pond series. High ammonia levels (> 5mg/l) may also form a constraint to the use of primary and sometimes secondary units for fish culture. Fish will not absorb pathogens into the meat but may retain them on the scales or in the gut. Consequently a small depuration or fish washing pond is advisable which should contain fresh water - if possible lightly chlorinated (use pot chlorinator). The fish should be retained in this pond for about a day prior to sale and consumption. Tilapia productivities of up to 10,000kg/ha/year have been reported (5).

5.14 There is obviously some health risk attached to the reuse of sewage effluent for irrigation and pisciculture. With the use of the standards and precautions outlined above, this risk is minimal. What small risk there is must be offset against the value of the recycled nutrient expressed in terms of increased crop yields or fish productivity. Furthermore, the reduction in health risk compared to that experienced with the use of night soil or raw sewage for irrigation or pisciculture is considerable.

5.15 Chlorination of effluents is seldom necessary or desirable for the following reasons:- !

- i) Possible risks associated with chlorinated hydrocarbons.
- ii) The resistance of many faecal bacteria to chlorine, resulting in aftergrowth.
- iii) Preferential uptake of chlorine by BOD, resulting in a high dosing rate and wastage of chlorine.
- iv) A well designed pond system can provide an effluent with < 100 Faecal Coliforms per 100ml, a high enough standard for unrestricted irrigation, without chlorination.
- v) Inability of chlorine to kill viruses, protozoa on helminths.
- vi) Maintenance is likely to be at best difficult, and at worst impossible, in most developing country locations.

Sewage Treatment Options

5.16 Table 5.2 shows some of the advantages and disadvantages of the most widely used sewage treatment processes.

TABLE 5.2

Advantages and Disadvantages of Various Sewage Treatment Systems

Criteria \ System	Activated Sludge Plant	Trickling Filter	Extended Aeration Plant	Oxidation Ditch	Aerated Lagoon	Waste Stabilisation Pond (including anaerobic units)	Waste Stabilisation Pond (excluding anaerobic units)
BOD_5 Removal	**	**	**	***	**	***	***
F.C. Removal	*	*	**	**	**	***	***
S.S. Removal	***	***	***	***	***	**	**
Helminth Removal	**	*	*	**	**	***	***
Virus Removal	**	*	**	**	**	***	***
Ancillary Use Possibilities	*	*	*	*	**	***	***
Effluent Reuse Possibilities	*	*	**	**	**	***	***
Simple and Cheap Construction	*	*	*	**	**	***	***
Simple Operation	*	*	*	**	**	***	***
Cheap Operation	*	**	*	**	*	***	***
Land Requirement	***	***	***	***	**	**	*

Key:
- *** Good
- ** Fair
- * Poor

5.17 This table highlights the many advantages of waste stabilisation pond systems which fare worse than the other systems only in S.S. removal (due to the algae in W.S.P. effluents) and the land requirement (climate dependent).

Climatic Factors

5.18 Climate is important inasmuch as the processes responsible for BOD_5 removal and faecal bacterial removal are temperature dependant. Furthermore algal photosynthesis depends on solar insolation, itself a function of latitude and cloud cover.

5.19 The pond liquid temperature is probably the parameter which has the greatest bearing on pond performance, and this often follows, and is a degree or two above the average ambient temperature. Periods of cloud are seldom a problem because the solar insolation during the day in tropical and sub-tropical regions generally greatly exceeds the saturation intensity of the algae present.

5.20 Since the bacteria providing treatment operate in the mesophilic temperature range (optimum 35°C), high temperatures are not a problem. Low temperatures can be, since they not only slow down the treatment process, but in the case of the methanogenic bacteria crucial to anaerobic digestion, virtually cease operation below temperatures of 15°C. Thus in areas where the pond liquid temperature remains below 15°C for more than a couple of months of the year, careful consideration should be given to the decision as to whether anaerobic units are desirable. Allowing for ponds to be about 3°C warmer than average ambient temperature, this would be in areas where the mean monthly average temperature was below12°C for two months or more.

Pond Design

5.21 Anaerobic ponds should be designed on the basis of volumetric organic loadings between 0.1 and 0.4 kg $BOD_5/m^3/day$. (100 to 400 grammes $BOD_5/m^3/day$). Values around 0.1 should be used for areas where there is a pronounced cold season, and 0.4 where there are uniform annual very warm temperatures. This is equivalent to an areal BOD_5 loading rate of between 2,500 and 10,000 kg BOD_5/ha/day, assuming an anaerobic pond depth of 4m; and to between 2.5 and 10 person served per cubic meter of pond volume assuming a BOD_5 contribution of 40 grammes per capita per day. The anaerobic pond detention time can be calculated by dividing the influent BOD_5 concentration in mg/l by the organic loading rate in grammes of BOD_5 per cu.m. per day.

There is theoretically no limit to how deep an anaerobic pond should be, although a depth of about 4m is reasonable and depths of less than 2.5m should not be used if possible. There appears to be little treatment advantage in extending anaerobic pond detention times to more than 2 days, although this may be inevitable with a high raw sewage BOD_5 and low permissible loading rate (14).

5.22 Anaerobic ponds should generally be constructed as parallel units, although where the loading rate is likely to build up slowly one unit may be constructed initially provided another can be added before the first requires desludging. When a third unit becomes necessary, it may be found desirable to operate two anaerobic ponds in series, and consequently the necessary pipework to enable the ponds to be used in parallel or series should be included in construction.

5.23 To ensure rapid development of both acid forming and methanogenic bacterial populations in anaerobic ponds, seeding with a stabilising sludge is advisable if this is possible. The best source for this sludge would be an existing sewage or night soil treatment plant of any type. Odour problems may result from treatment of wastes with a sulphur concentration $>$100mg/l (as sulphate), in which case anaerobic ponds should be avoided. Methane fermentation is inhibited by a ph 7 and highly acidic raw waste requires ph elevation before treatment in anaerobic ponds by dosing with alkaline salts.

5.24 Many different design procedures have been recommended for facultative ponds (15,16,17,18,19), although in hot climates temperature based methods should be used unless long cool and very overcast periods are experienced, in which case other methods may need to be considered. The simplest method relates possible areal loading rate expressed in kg BOD_5/ha/day to minimum monthly average temperature. Several relationships have been recommended (18,19,20), but the one providing best agreement with all the available data is:

$$\text{areal loading rate } \lambda_s = 20T - 20 \qquad \text{----- (1}$$

Where λS is the areal loading rate in Kg BOD_5/ha/day and T is the minimum mean monthly ambient temperature in ^oC.

This provides a safety factor of about 1.5 before complete failure of a facultative pond according to most data (19,20,21) although failure at slightly lower loadings has been observed in South America (8). The area may be calculated using the formulae:

$$A = \frac{10\ L_i\ Q}{\lambda_s} \qquad \text{--------- (2}$$

where A = facultative pond area in m^2
L_i = influent BOD_5 concentration in mg/l
Q = influent flow rate in m^3/day

and λ_s is defined above.

5.25 For design temperatures between 15 and 30°C and assuming a BOD_5 contribution of 40grammes/capita/day, equations 1 and 2 give between 7,000 and 14,500 people served per hectare of facultative pond. Depths for facultative ponds of between 1.5 and 1.8 meters are generally used although there appears to be no reason why greater depths should not be used to increase detention times and thus bacterial removal, although areal organic loading is, of course, independent of depth.

5.26 Where a facultative pond forms the primary unit in a series, it is advisable to provide for pond desludging when this becomes necessary by providing a pond bypass or by the construction of parallel units. These measures may be avoided if facultative ponds are made sufficiently deep so as not to require desludging during their lifetime.

5.27 Maturation ponds should primarily be designed to achieve faecal bacterial removals. The design procedure assumes faecal coliform removal is a first order kinetic reaction given by:

$$B_e = \frac{B_i}{1 + K_{B(T)}t^*} \qquad \text{--------- (3}$$

where B_e = bacterial concentration in No.F.C./100ml of effluent.

B_i = bacterial concentration in No.F.C./100ml of influent.

$K_{B(T)}$ = first order F.C. removal rate constant at T°C in day $^{-1}$.

t^* = detention time

Due to this form of removal, it can be shown (22) that removal is more efficient with a greater number of ponds for the same total detention time, and with all these ponds each having the same detention time.

Furthermore, the first order removal rate constant has been shown (20) to be retarded with increasing time as well as reducing temperature. Thus a series of maturation ponds with a detention time of about 5 days is recommended, the number used depending on the effluent standard required. For general purposes the following equation may be used for calculation of the value of $K_{B(T)}$.

$$K_{B(T)} = 2.6(1.19)^{(T-20)} \qquad \text{-------} \ (4)$$

The total faecal coliform removal in a series can be found from:

$$B_e = \frac{B_i}{(1+K_{B(T)}\ t^*_{an})(1+K_{B(T)}\ t^*_{fac})(1+K_{B(T)}t^*_{mat})^n} \quad \text{---}(5)$$

where t^*an, t^*fac, and t^*mat are the detention times of the anaerobic, facultative and maturation ponds respectively and n is the number of maturation units.

5.28 As an alternative to a series of maturation ponds, one large reservoir may be constructed, as is the practice in Israel. Bacterial removal is less efficient (e.g. using equations(4) and(5), 3 No. 5 day ponds give a bacterial removal equivalent to 1 No. reservoir with a detention time of 554 days), but under certain circumstances, particularly where irrigation requirements are seasonal, a large and deep (6 to 8m) reservoir may provide adequate maturation and prove cheaper than a greater number of smaller and shallow maturation ponds. Maturation ponds are generally shallow (1.2 to 1.5m) to maintain largely aerobic conditions, with the added advantage that viral removals are better in shallow than in deep ponds. Where reservoirs are used care should be taken to ensure that adequate bacterial removals are achieved when the reservoir is drawn down. The light organic loading and deep aerobic surface layer on the reservoirs ensures no nuisance results from any anaerobic activity below the surface layers, which should be minimal.

5.29 Pond systems may be designed so that there is no effluent discharge, i.e.with inflow equal to seepage plus evaporation. In such cases particular care should be taken to ensure that groundwater pollution is minimised and that water resources are not put under risk. The area of ponds required for such a system is large, assuming losses of about 10mm per day, approximately 10 m^2 of pond area would be required per capita.

5.30 Design of aerated lagoons may be based on assumptions of first order BOD_5 removal (23,24,25). However, empirical design is generally used, a 4 day detention time achieving 80 to 90% BOD_5 removal in a partially mixed aerated lagoon. Power requirements are about 4 watts/m^3 for a partially mixed lagoon and 20 watts/m^3 for one which is completely mixed. A lagoon depth of about 3m is generally used.

5.31 Table 5.3 shows anticipated BOD_5 and Faecal Coliform removals for pond systems including and excluding aerated lagoons and anaerobic ponds at 20°C. Table 5.4 shows the effect on Faecal Coliform concentrations of 1,2 and 3 maturation ponds at 12°C, 20°C and 25°C. Table 5.5 gives the net pond area and detention times for various pond systems serving a range of populations at 12°C, 20°C and 25°C.

Other Design Considerations

5.32 Flow measurement should be facilitated by provision of a V notch at the inlet to, and where appropriate at the outlet from, the pond system. Where the flow rate exceeds 10,000 m^3/day and the required technical staff are available, a ventri flume may be preferred to a V notch, allowing continuous monitoring of flow rate.

5.33 Some kind of pretreatment should always be included to provide removal of large solids which would otherwise float on the pond surface causing nuisance and scum formation, or where applicable would foul aerators. Screens are preferable to comminutors, being cheaper and easier to maintain. At systems without a labourer permanently on duty one fairly course screen which will not require too frequent cleaning is sufficient. Where there is someone on duty 24 hours a day, a course screen followed by a fine screen may be used. Mechanically raked screens often prove unreliable and should only be used as secondary screens if at all. Screenings should be burnt or buried.

5.34 Grit channels or detritus tanks may be avoided by deepening the primary ponds around the inlet. With larger facilities ($>$10,000 m^3/day) or where the raw sewage contains large amounts of grit or sand, grit channels or detritus tanks are required. These should be constructed in parallel and if possible should be manually cleaned. Where grit removal facilities are excluded, the grit sump at the inlet to the primary pond should be designed for 2 year emptying frequency in anaerobic ponds and

TABLE 5.3

Anticipated BOD_5 and F.C. Cumulative Percentage Reductions for Various Pond Systems at 20°C

	cum.% BOD_5 reduction	cum.% F.C. reduction
Anaerobic pond	65	95
an. + fac.	85	99.80
an. + fac. + mat	92	99.985
an. + fac. + 3 x mat.	95	99.999
Facultative pond	80	99
fac. + mat.	90	99.90
fac. + 3 x mat.	95	99.995
Aerated Lagoon	85	95
aer. + mat	92	99.70
aer. + 3 x mat.	95	99.990

Note: Maturation ponds assumed to have 5-day detention times.

Key:
- an. anaerobic pond
- fac. facultative pond
- mat. maturation pond
- aer. aerated lagoon

TABLE 5.4

Effect on F.C. Content of Maturation Ponds of 5-day Detention Time at 12°C, 20°C and 25°C

	Temperature		
F.C. Conc./100ml	12°C	20°C	25°C
Inflow to first maturation pond	1,000,000	1,000,000	1,000,000
Para 1 Effluent	69,930	62,500	31,250
Pond 2 Effluent	4,890	3,910	976
Pond 3 Effluent	342	244	30

TABLE 5.5

Predicted net pond area requirements and system detention times to satisfy effluent standard < 25mg/l BOD_5 and < 5,000 F.C./100ml

System	Detention Time Days			Population Served	Pond Area, ha			Power Requirement KW
	12°C	20°C	25°C		12°C	20°C	25°C	
Anaerobic pond plus facultative pond and maturation ponds.	29.7	18.8	13.0	10,000	2.2	1.6	1.1	-
				25,000	5.5	4.0	2.6	-
				50,000	10.7	7.7	5.1	-
				100,000	20.9	15.1	10.0	-
				250,000	50.8	36.5	24.3	-
Facultative pond plus maturation ponds	48.9	25.4	17.6	10,000	3.9	2.0	1.4	-
				25,000	9.5	4.9	3.5	
				50,000	18.5	9.4	6.8	-
				100,000	36.4	18.5	13.3	-
				250,000	88.2	44.9	32.2	-
Aerated lagoon plus polishing ponds	34.0	21.0	16.9	10,000	2.6	1.8	1.3	25
				25,000	6.3	4.3	3.2	63
				50,000	12.3	8.4	6.3	125
				100,000	24.1	16.5	12.3	250
				250,000	58.5	39.9	29.9	630

Note: Assumptions

Water consumption 130 litres/capita/day.
Percentage water reaching sewers 80%.
BOD_5 contribution 40 grammes/capita/day.
Depth of ponds - anaerobic 4m
facultative 1.8m
maturation 1.5m
aerated lagoon 3m
Detention times - maturation ponds 5 days
aerated lagoons 4 days

F.C. in raw sewage 2×10^7/100ml.

longer in facultative ponds if possible. The invert level of the sump should be at least 1m below the invert level of the pond with sides sloping at about 1 in 2. The pond inlets should be designed to give as high a velocity and as good a dispersion of the influent as possible, to try and ensure disposal of settleable solids over the full area of the sump.

5.35 Removal of the detritus collected in the sump should be carried out at the same time that sludge is removed from the primary pond. This should be when the pond becomes half full of sludge; about two years for a primary anaerobic pond and perhaps 10 years for a primary facultative pond. Secondary facultative ponds should not require desludging more frequently than every 20 years, and may never need desludging during the life of the pond system. Sludge depth can be determined by sampling a column of pond liquid in a clear plastic tube or by feeling for the top of the sludge blanket with a disc on a vertically held pole. Where desludging is required frequently, (i.e. anaerobic ponds and possibly facultative ponds incorporating a grit sump), and where a long dry season is likely to allow sludge drying and hence removal by excavation, a concrete or pitched stone access ramp should be provided.

5.36 Algae may cause a problem in the pond system final effluent if it is to be used for drip irrigation (clogging) or discharged to a small watercourse (dissolved oxygen depletion downstream). Algal concentration will reduce with an increasing number of maturation ponds as the nutrient concentration reduces. If further removal is required, a number of methods are available but all are expensive and difficult to maintain (7). The least complicated of these is a pebble bed clarifier which will reduce algal concentration by about 50%. A similar reduction can be achieved by a horizontal rock filter which may be constructed in the pond before the outlet and avoids the construction and backwashing problems of the pebble bed clarifier. The rock filter uses 35 to 50 mm grading, and the effluent should be retained for about 24 hours in the filter. Drawing the effluent off from below the surface layers remains the best method of reducing algal concentration in the effluent, although this may have repercussions on other effluent parameters (e.g. bacterial concentration).

5.37 Containing algal growth is possible using compounds which inhibit algal respiration and photosynthesis. However, this is undesirable since it is likely to interfere with the treatment process.

5.38 Odour nuisance from overloaded facultative or anaerobic ponds may be controlled by using forced mechanical aeration or effluent recirculation to provide an oxidising environment at the pond surface. Provision for addition of aerators or future recirculation does add to the flexibility of the system and provides an insurance against possible future nuisance problems, however, the capital cost of the system is likely to increase. If aerators are added these should be floating direct vertical drive type, positioned so as to avoid dead areas. It must be remembered that inclusion of aeration or recirculation will dramatically increase the maintenance requirements and operational costs of a pond system.

Pond Location

5.39 The most important factor in pond location is generally one of where the land is available in sufficient quantities. If large areas of land are available reasonably close to the centre of population and can be acquired cheaply, then other factors might have to be adapted to this site.

5.40 This land should preferably be adjacent to a disposal facility, and for pond effluents there are many advantages to be gained from using land disposal by irrigation rather than discharging directly to a river or watercourse.

5.41 The pond system should wherever possible be at a lower level than the contributing population, thus allowing discharge to the ponds under gravity. If pumping is required, pumping of the effluent is preferable to pumping the raw sewage (smaller volume and less large solids).

5.42 The ideal location for ponds is on gently sloping land, and on impermeable soil. If this is not possible there should preferably be a supply of clay close by for use as a pond lining or in embankment construction. Some degree of percolation may not cause a problem where the groundwater is not used as a water resource, and here ponds may be constructed of a more permeable material.

5.43 It is generally recommended that wherever possible, pond systems should be located at least 500m from the nearest residential area and where anaerobic ponds are also used, this distance should ideally be increased to 1km. Although these distances should be recommended, there are many examples of people living within 100m of pond systems without suffering any nuisance. One precaution which can be taken if pond systems are very close to residential areas is to place anaerobic units at the centre of the system, thus minimising any effects on the community resulting from poor control of possible fly breeding on the pond crust.

5.44 To minimise the nuisance caused if any odour problems do develop, pond systems are best situated to the leeward of contributing communities for night time prevailing winds.

5.45 Areas which include old river beds or similar topographical or geological features should not be used for pond systems unless:

i) The effluent is not to be reused and groundwater pollution from the high rate of percolation will not threaten water resources.

ii) The cost of lining the pond system with plastic sheeting or impermeable soil can be borne.

5.46 Sites with high water tables should be avoided for the construction of pond systems if possible since use of heavy machinery close to, or below, the water table can cause problems. In such cases alternative methods of embankment construction such as manual methods or use of drag lines may have to be considered.

5.47 Wherever possible pond systems should be situated so as to avoid wind shadows. Furthermore, to aid wind mixing the ponds should as far as possible be constructed with their longest dimension parallel to the prevailing wind direction.

5.48 The siting of the pond system may be constrained to some extent by the position of the outfall sewer where an existing sewerage system is being served.

Civil Engineering and Earthworks

5.49 Good earthwork guidelines are contained in the general specification for the Israeli Sewerage Project produced for the World Bank funded Israeli Sewerage Project.

5.50 Soil sampling and testing should be carried out to determine the compactability and permeability of the soil at the site, and of any offsite material to be used in construction. Compaction and permeability tests shall be conducted according to A.S.T.M. or B.S.I. Standards or equivalent.

5.51 All areas on which construction is to take place, including pond areas, shall be cleared of all vegetation together with roots and all other deleterious matter. Top soil shall be stripped to a minimum depth of 150mm, and unsatisfactory or weak soil shall be excavated. This material shall be stored for reuse, but on no account shall it be used as compacted fill in embankment construction.

5.52 The excavations shall be operated in such a way as to yield the maximum of materials suitable for construction purposes. These materials shall be stored in temporary stockpiles for later placing in designated locations. Excavated materials which are unsuitable for reuse or are in excess of material required for reuse should be removed from the site. Additional material required for compacted fill in embankments should be excavated from borrow pits after shipping of topsoil and other unsuitable material.

5.53 The embankments shall be constructed with a top width sufficient to allow passage of a small truck (i.e. width 3m), and with side slopes as steep as is possible and also consistent with slope stability, minimal slope erosion and ability of earth moving machines to work on the slope (generally a slope of 3:1).

5.54 Embankment foundations shall be suitably prepared before the placing of material for embankment construction. In clayey cohesive soils the foundations shall be scarified, wetted and compacted to 95% modified AASHO dry density standard or equivalent, or as specified for the earthfill to be placed thereon. In sandy or gravelly uncohesive soils, the foundations shall be compacted by vibrating rollers to a depth of not less than 300mm to the same relative density as specified for the overlaying earth fill (normally 70% relative density or equivalent). Foundation surfaces shall be moistened before placing the first layer of earth fill. Where an impermeable core is to be used in embankment construction, a key trench should be excavated along the line of the embankment and compacted and prepared as described above.

5.55 Embankment construction materials shall be placed in horizontal layers over the entire embankment width. For clayey and silty cohesive materials these layers shall not exceed 150mm thick after compaction. Optimum moisture content shall be maintained during compaction which shall be to not less than 95% of the modified AASHO dry density. For sandy and gravelly cohesionless free draining materials the thickness of horizontal layers after compaction shall be not more than 300mm if crawler tractors or surface vibrators are used, and 150mm where tampers and rollers are used. Compaction shall be to relative density of not less than 70%. For borderline cases between cohesive and cohesionless soils, 70% relative density or 95% modified AASHO dry density should be achieved, whichever is the higher. At least six passes of compacting equipment is required in any case, and the overlapping of adjacent passes shall be not less than 300mm.

5.56 Where manual excavation and embankment construction are used, and where access by machine is not possible, hand tamping of layers shall be carried out to achieve the same densities as above. The thickness of such compacted layers shall not exceed 150mm.

5.57 Where embankments are constructed of uncohesive free draining soils, some form of sealing will generally be required. This may be an impermeable embankment core, a clay blanket on the inside embankment slope, or a plastic sheet lining. If an impermeable core is used construction shall be carried out as outlined above, with the core material laid in layers not exceeding 150mm in thickness after compaction. In the case of a clay blanket, this shall be laid on the inside of theembankment in a layer not less than 200mm thick after compaction to 95% modified AASHO dry density standard. If this density cannot be achieved a thicker clay blanket shall be used.

5.58 Outside embankments shall be seeded with grass or some other suitable ground cover to minimise erosion. Inside embankments shall as far as possible be made to resist root taking and accept weed prevention sprays. A hard edge shall be provided at the water surface level around the entire perimeter of the pond, extending at least 200mm above and below the water surface level. This edge detail is to avoid embankment damage caused through wave action and should ideally comprise either concrete slabs or grouted rip rap. The embankment crest should be provided with an all weather surface.

5.59 Pond details should incorporate the following:-

i) Multiple submerged inlets to the primary pond.

ii) Preferably variable level outlets or otherwise outlets drawing off from just below the surface, and well below the surface from the final pond.

iii) Submerged inlets to all ponds.

iv) Measuring devices at inlet and outlet of system.

v) Bypass for the pretreatment and primary pond in the system.

vi) Draw down facilities for the primary units.

N.B. In small plants it may not be reasonable or affordable to incorporate all these items, or to keep to the specification outlined above.

Expansion of Pond Systems

5.60 There are several ways in which the capacity of a pond system can be increased, and these are:

i) Additional units in series
ii) Additional units in parallel
iii) Excavation to give increased pond depth
iv) Any or all of i) to iii) plus embankment removal to provide one large pond from two or three small ones.

This increased capacity will result in increased treatment efficiency or ability of the system to handle a greater volume of wastewater, or both. Such structural changes may be preferred to installation of aerators or recirculation with the associated operational problems and additional costs.

5.61 Where it is planned to progressively increase the wastewater flow to a pond system over a long period of time, the use of parallel systems is probably preferable. Additional pond series can be constructed in parallel with existing units, using one common embankment. Thus, as each new series becomes necessary, one embankment running the full length of the system is already constructed. The inlet and outlet works may be designed to take the total future design flow as part of the initial construction stage. The Dandora pond series in Nairobi is an excellent example of this type of system.

5.62 Where planning has not been so far-sighted and a pond system becomes overloaded, construction of additional units in series may be the most satisfactory method. Previously constructed embankments can also be utilised in this case. For instance, constructing an anaerobic pond to reduce loading on an existing facultative pond, or providing an additional maturation pond to improve effluent quality. An example of this system of expansion is Einshemer in Israel.

5.63 Excavation to give increased pond depth causes particular problems in that the ponds must be emptied before the extensions can be carried out. This problem may be overcome if the opportunity to increase pond depth is taken when pond cleaning is carried out. This was one of the features of the extension and rehabilitation of the Ramat Hasharon ponds in Israel. Increased pond depth results in increased detention time of the system and will allow a grossly overloaded facultative pond which may be causing odour nuisance to operate as an anaerobic pond, or enable aerators to be used if so desired.

5.64 Combining several ponds in a pond system to create one larger unit also suffers from problems related to the need for all the ponds involved to be emptied. The advantages of such a system are that additional volume and pond surface area can be created without the need for any additional land or construction. It should be borne in mind that the treatment efficiency would be unlikely to improve after such modifications since the system as a whole would be operating less as a plug flow reactor and more as a completely mixed reactor. However, such modifications could be justified if increased effluent storage was required for irrigation, or where it was desired to combine existing anaerobic ponds to make a single aerated lagoon (thus increasing detention time closer to the four days required for aerated lagoons).

Operation and Maintenance

5.65 Waste stabilisation ponds are unique amongst sewage treatment systems in their ability to continue in operation, providing a high quality effluent, despite poor or even non existent maintenance. However, regular maintenance should be carried out to maintain a high standard of effluent, to avoid nuisance problems which may otherwise develop, and to avoid rapid physical depreciation of the system.

If pond systems cannot be properly maintained, then there is no hope whatsoever that any other sewage treatment plant can be maintained.

5.66 The operation and maintenance duties for a typical waste stabilisation pond system include the following major items:-

i) Where manual bar screens and or grit channels are used, regular cleaning and daily burial or burning of screenings and detritus, or removal from site, should be carried out.

ii) Where automatically operated bar screens and grit removal chambers are used regular routine lubrication of the working parts should be carried out and frequent checks on the operational efficiency of the equipment should be made. Equipment of this nature should only be used for very large systems in areas where mechanical equipment is widely used, and wage levels are high preventing the employment of large numbers of labourers.
Screenings and detritus should be disposed of as above.

iii) Embankment vegetation should be kept short and not be allowed to extend into the ponds. Grass may be permitted to grow down to the edge protection slabs where these are used. Otherwise the water's edge should be sprayed with weed killer.

iv) Scum on facultative ponds should be removed and broken up. Scum and algal mats should not be left at the water's edge but should be dried and disposed of to any nearby grassed area. Scum on anaerobic ponds aids the treatment process and should be left to form a hard crust, but sprayed to prevent any fly breeding.

v) Inlets and outlets should be kept free from accumulating solids.

vi) Any vegetation emerging through the hard edge protection or from the pond liquid should be removed.

vii) Where appropriate, regular records should be kept of flow rates into and out of the pond system, and the influent and effluent quality should be regularly monitored.

5.67 In addition to the above duties, general repairs to the structural elements such as fencing and embankments must be carried out. Guards should be provided at plants where there are buildings and mechanical equipment, which will otherwise be subject to burglary and vandalism.

5.68 Pond monitoring can be carried out at two levels. Smaller systems are unlikely to be provided with laboratory facilities, although efforts should be made to have occasional checks made on influent and effluent quality so that potential overloading may be predicted, and effluent quality can be checked against standards required. This is particularly important where fish culture or irrigation are practised. Laboratories must be found to make these occasional checks, possible sources being neighbouring treatment plants, universities, regional laboratories or private laboratories. With large systems which include their own laboratory, the necessary equipment and staff should be obtained to allow measurement of the BOD_5 and faecal coliform concentrations at the very least. Measurement of in-pond parameters such as the dissolved oxygen and ph is also important in checking whether the ponds are operating satisfactorily.

5.69 The recommended staffing levels for systems serving populations of 10, 25, 50, 100 and 250 thousand in an area where labour is relatively cheap are shown in section 4.16 above.

Land Requirements and Costs

5.70 Where land is difficult to find or very expensive, attempts can be made to trade for the land by encouraging the client:-

i) to offer the owner the right to the effluent.

ii) to offer tax or rate concessions to the landowner.

iii) to exchange municipally owned land for the required land.

5.71 The price of land invariably rises with time, regardless of the cost at time of purchase. Thus it is not possible to put a price on land above which ponds are no longer an economical solution to wastewater treatment problems. The question is more one of whether there is the necessary finance and the demand to make it possible for the available land to be developed immediately. If the land is potentially developable in the short term, and no other land is available for the treatment system, then it will be difficult to justify the use of waste stabilisation ponds.

If, however, there is no immediate pressure to develop the land, its purchase for the construction of waste stabilisation ponds, at whatever cost, may be regarded as an investment as well as allowing construction of a wastewater treatment system.

5.72 Where large areas of land are available outside the city or town which are suitable for the construction of a pond system, then arguments against the use of ponds are difficult to sustain. Land right on the edge of urban development which is reasonably expensive can still be used for ponds if the client can be convinced of the investment value of land bought now, which in 20 years when the city development has encroached on the ponds will be worth several times as much. This land can be sold to developers once the ponds become obsolete.

5.73 The major factors which affect the amount of the land required for the construction of a pond system are:-

- i) Contributing population.
- ii) Wastewater and organic contribution per capita.
- iii) Temperature
- iv) Type of system used (i.e. inclusive or exclusive of anaerobic ponds).

5.74 The major factors which effect the cost of a pond system are:-

- i) The cost of land
- ii) The type of soil (i.e. permeable soils mean pond lining likely - considerably increased costs)
- iii) The type of system used.

5.75 The major factors affecting the operational costs of the pond system are:-

- i) Wage rates
- ii) Amount of mechanical equipment used
- iii) Level of maintenance

5.76 Table 5.6 shows the approximate total site area requirements, capital costs and operating costs for pond systems serving between 30,000 and 100,000 population. These figures should be treated as very rough guidelines in view of the many variable factors for which assumptions have had to be made.

5.77 Use of more mechanically intensive sewage treatment systems should be avoided under any circumstances and other systems should only be considered where there is already experience of such systems in the area. Where consideration is given to other more mechanically intensive waste treatment methods as well as ponds, factors other than the purely financial should also be considered. Weighting in favour of pond systems should reflect the absence of mechanical equipment and the consequently increased reliability of the system. However, this will often not be necessary since pond systems may form the least cost feasible solution to sewage treatment problems in any case.

TABLE 5.6

Approximate per capita requirements for a waste stabilisation pond system serving a total population of between 30,000 and 100,000

Effluent standard 100 F.C./100ml.

	With Anaerobic Pond		Without Anaerobic Pond	
	25°C	12°C	25°C	12°C
Land per capita (gross), m^2	2.0	3.9	2.5	6.0
Capital cost US$/capita	20	30	25	40
Operational cost US$/capita/ annum	0.5	0.7	0.5	0.7

Effluent standard 1,000 F.C./100ml

	With Anaerobic Pond		Without Anaerobic Pond	
	25°C	12°C	25°C	12°C
Land per capita (gross), m^2	1.7	3.4	2.2	5.5
Capital cost US$/capita	18	28	23	38
Operational cost US$/capita/ annum	0.4	0.6	0.4	0.6

Effluent standard 10,000 F.C./100ml

	With Anaerobic Pond		Without Anaerobic Pond	
	25°C	12°C	25°C	12°C
Land per capita (gross), m^2	1.4	2.9	1.9	5.0
Capital cost US$/capita	15	25	20	35
Operation cost US$/capita/ annum	0.3	0.5	0.3	0.5

Note: Assumes no pond lining required
Land costs excluded

LEAST COST FEASIBLE SOLUTION ANALYSIS

6.1 To demonstrate the way in which a waste stabilisation pond system will often provide the least cost feasible solution in spite of relatively high land costs, an example is given below. This compares costs calculated on a life cycle discounted cash flow basis for four different systems. These are:-

- i) Waste stabilisation pond system, comprising anaerobic, facultative and maturation ponds in series.
- ii) Aerated lagoon system, comprising aerated lagoons, facultative and maturation ponds in series.
- iii) Oxidation ditch system comprising oxidation ditches, humus tanks and sludge drying beds.
- iv) Biological filtration plant comprising primary sedimentation tanks, biological filters and humus tanks with associated sludge drying beds.

6.2 In order that reasonably reliable relative cost data can be used, the basic unit costs have been taken from a report on feasibility studies for sewage treatment in the city of Sana'a (26). The estimates for operational costs for the systems evaluated in this Sana'a study are also used as a basis for the operational and maintenance costs assumed hereunder. The designs for the oxidation ditch system and trickling filter plant considered below are also based on the designs presented in the Sana'a paper.

6.3 All the costs used have been converted to U.S. dollars (5 Yemeni Rials = US$1).

6.4 The following assumption have been made in the system designs.

Contributing population	250,000
Wastewater contribution	120 l/c/d
Average daily wastewater flow	30,000m^3/d
Per capita BOD_5 contribution	40g/c/d
Average daily BOD_5 contribution	10,000 kg/d
Controlling temperature	20^oC
F.C. concentration in raw sewage	2 x 10^7F.C./100ml
Effluent standard for BOD_5	25mg/l
Effluent standard for F.C.	10,000 F.C./100ml
Pumping required to inlet works and for irrigation	

6.5 Waste stabilisation pond system assumptions:

Depths -	anaerobic ponds	4m
	facultative ponds	1.8m
	maturation ponds	1.5m

2 parallel streams of ponds

Total site area required 46 ha.

6.6 Aerated lagoon system assumptions.

Partially mixed primary aerated lagoon

Detention time of aerated lagoons	4 days
Depth of aerated lagoons	3.5m
Depth of facultative ponds	1.75m
Depth of maturation ponds	1.0m

2 parallel streams of ponds

Total site area required 50 ha.

6.7 Oxidation ditch assumptions:

Detention time in ditches	1 day
Detention time in settlement tanks	4.5 hours
Sludge drying bed area	10 persons/m^2

Total site area required 20 ha.

6.8 Trickling filter assumptions:

Primary sedimentation tanks detention	6 hours
Biological filter media depth	2m
Up to 2 x average flow recirculation rate	
Secondary sedimentation tanks detention	6 hours
Sludge drying bed area	8 persons/m^2

Total site area required 25 ha.

6.9 Capital Costs of Systems in US$.

	Land*	Earthworks	Structures	Equipment
Waste Stabilisation Ponds	400,000	2,300,000	2,500,000	200,000
Aerated Lagoon System	500,000	2,500,000	3,000,000	1,100,000
Oxidation ditch	200,000	200,000	4,100,000	1,300,000
Trickling Filter	250,000	180,000	7,500,000	1,900,000

* Land assumed to cost US$1 per m^2.

6.10 Total capital costs, including land for each system are estimated at:

Waste stabilisation pond system	US$5.4m	(US$22/capita)
Aerated lagoon system	US$7.1m	(US$28/capita)
Oxidation ditch system	US$5.8m	(US$23/capita)
Trickling filter system	US$9.8m	(US$30/capita)

6.11 Operational costs including power consumption etc. are assumed as follows:

Waste stabilisation pond system	US$ 50,000/annum	(US$0.2/capita)
Aerated lagoon system	US$300,000/annum	(US$1.2/capita)
Oxidation ditch system	US$350,000/annum	(US$1.4/capita)
Trickling filter system	US$200,000/annum	(US$0.8/capita)

6.12 Benefits accrued from irrigation with effluent are assumed equal for all systems since additional value of algae as soil conditioner will depend on type of soil at pond location. With irrigation water sold at US$1 per m^3, value in first year will be US$100,000 per annum.

6.13 The maturation ponds in the waste stabilisation pond system and some of the polishing ponds in the aerated lagoon system may be used for fish farming. If 18ha of pond is used for fish culture in each case; with a productivity of 4,000 kg fish/hectare/annum, a total yield of 72 tonnes of fish per annum might be achieved. Allowing this fish to be conservatively priced at US$1 per kg, this means an income in the first year of US$72,000.

6.14 Assuming the treatment systems to have a 20 year life, the land on which they stand may be resold for development after this period. It is assumed that the value of this land purchased at US$1 per m^2 will have risen to US$5 per m^2 as the city encroaches on the site. Thus the value of the land released from each system, once prepared for development, will be as follows:

Waste stabilisation ponds	US$2.3m
Aerated lagoon system	US$2.5m
Oxidation ditch system	US$1.0m
Trickling filter system	US$1.3m

6.15 Before this land can be reused some preparation will be required (e.g. draining and/or levelling for pond systems; removal of concrete structures for oxidation ditch and trickling filter systems). The costs of this work are estimated below:

Waste stabilisation pond site - drainage and levelling US$200,000

Aerated lagoon site - drainage, levelling and removal of structures US$300,000

Oxidation ditch site - levelling and removal of structures US$500,000

Trickling filter site - levelling and removal of structures US$500,000

6.16 Bringing the operation and maintenance costs and income derived from irrigation and fish farming to present values, an opportunity cost for capital of 5% is assumed. This gives:

	Op.&Maint. Cost	Irrigation Income	Pisciculture Income
W.S.P. system	0.6m	1.25m	0.9m
A.L. system	3.7m	1.25m	0.9m
O.D. system	4.4m	1.25m	-
T.F. system	2.5m	1.25m	-

All figures present values in US$ over 20 years assuming 5% opportunity cost for capital.

6.17 Thus net present values for each of the proposed systems can be calculated as follows:

i) Waste stabilisation pond system

Costs -	Capital cost (inc.land)	5.4m
	Operating cost	0.6m
	Preparation cost of land before resale possible	0.2m
		6.2m
Benefits -	Resale of land	2.3m
	Irrigation income	1.25m
	Pisciculture income	0.9m
		4.45m

Net present value - 1.75m

ii) Aerated lagoon system

Costs -	Capital cost (inc.land)	7.1m
	Operating cost	3.7m
	Preparation cost of land before resale possible	0.3m
		11.1m
Benefits -	Resale of land	2.5m
	Irrigation income	1.25m
	Pisciculture income	0.9m
		4.65m

Net present value - 6.45m

iii) Oxidation ditch system

Costs -	Capital cost (inc.land)	5.8m
	Operating cost	4.4m
	Preparation cost of land before resale possible	0.5m
		10.7m
Benefits -	Resale of land	1.0m
	Irrigation income	1.25m
		2.25m

Net present value - 8.45m

iv) Trickling filter system

Costs -	Capital cost (inc.land)	9.8m
	Operating cost	2.5m
	Preparation cost of land before resale possible	0.5m
		12.8m
Benefits -	Resale of land	1.3m
	Irrigation income	1.25m
		2.55m

Net present value - 10.25m

Thus on this analysis a waste stabilisation pond system appears to offer the most economic solution in this case.

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Volume 2

Pur. general - Doc.

INTERNATIONAL BANK FOR
RECONSTRUCTION AND DEVELOPMENT

URBAN PROJECTS DIVISION

A REVIEW OF WASTE STABILISATION PONDS

FINAL DRAFT

A REPORT BY

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DECEMBER 1981

V O L U M E II

A N N E X E S

CONTENTS

NOTE

In order to enable cost comparisons to be made between the various pond systems described in Annex C, the approximate current value of each of the currencies in terms of the US$ is given below.

Philippines	8 Pesos	=	1 US dollar
India	9 Rupees	=	"
Israel	15 Shekels	=	"
Kenya	10 Kenyan shillings	=	"
Zambia	0.88 Kwacha	=	"
Jamaica	1.8 Jamaican dollars	=	"

ANNEX A.

WORLD BANK / INTERNATIONAL FINANCE CORPORATION

OFFICE MEMORANDUM

TO: Mr. Jim Arthur, Cons., Gilmore Hankey Kirke Partnership DATE: April 24, 1981

FROM: David B. Cook, Acting Assistant Director, URB

SUBJECT: **Stabilization Pond Review**
Terms of Reference

Foreword

1. The Urban Projects Department wishes to undertake a review of the operational experience of designing, constructing and operating waste stabilization ponds. The work is not confined to ponds financed and/or under supervision by the Urban Projects Department; it is being carried out with the support and collaboration of the Senior Adviser, Water and Wastes (Transportation, Water and Telecommunications Department) and the regionalized urban and water divisions.

Background

2. There is broad agreement among design professionals, particularly in the West, that stabilization ponds can at times be an ideal solution to the treatment of sewage. They frequently offer a least cost, minimum maintenance solution, work well in warm sunny climates, and as such are ideally suited to LDCs. Yet many Bank borrowers need convincing of their viability and in some countries there is opposition to using them for reasons that cannot be well substantiated.

3. A number of papers and books describing the hydraulic and biochemical design and operation of ponding systems exist, but a useful summary of some of the practical experiences in locating, designing, bidding, constructing and operating sewage treatment ponding systems which is of use to non-technical as well as sanitary engineers remains to be written. The objective of these terms of reference is to produce such a summary.

4. Throughout the assignment emphasis must be placed on the practical aspects. A working list of do's and dont's, opportunities and cost savings is as, if not, more important in this work than a detailed analysis of the biochemical process. Lack of operational knowledge based on actual experience, or misconceptions, make clients unsure about using the system and disapproval of ponding is often couched in terms which cannot be wholly rationalized, yet are hard to dispute. It is the intention to use the findings of this review in our dialogue with borrowers to encourage the pursuit of rational policies and the development of appropriate technology alternatives for sewage treatment.

Scope of Work

5. On or about May 12 you will commence a review of design, construction and operation experience in some of the stabilization ponds constructed with Bank finance.

6. You will visit ponds in Philippines, India, Israel, Kenya, Zambia, and Jamaica. In Israel you will be joined by Shaul Streit (separate terms of

reference). Following is a checklist of items to be considered and reviewed:

Design

(a) discuss the clients' reactions to the use of ponds as a design solution and whether opposition to the use of ponds had to be overcome at the review of sewage treatment alternatives before design actually started;

(b) hydraulic, biochemical, and civil engineering design criteria: review alternatives considered in design; number of ponds, configuration, depth, and selection of preferred solution, extent to which land costs were traded off between ponds and other alternatives, e.g. aerated lagoons, whether ponds were designed to allow for future increased inflow, (e.g. by subsequently adding aeration units or by land reservation); evaporation and percolation forecasts; procedures for dealing with temperature variation (if any) and for coping with prolonged cold periods. Capacity of ponds to cope with industrial or trade effluents;

(c) soil: soil used in embankments, compaction achieved, whether lined or not; type of wave action protection of levees; percolation issues;

(d) fencing: type and brief specification;

(e) landscaping: grass and tree planting and provision for maintenance (if any);

(f) lighting: types of columns and lanterns, if provided;

(g) laboratory: building construction, furniture and testing equipment provided;

(h) land issues: net area of ponds, gross area of treatment site, site selection, inter alia comment on the human factors which make a sewage treatment ponding system acceptable or give rise to strong opposition;

(i) ancillary uses: has harvesting of algae been considered, fish farming or other alternative ancillary uses;

(j) effluent reuse: describe possibilities (if any) and whether effluent used for irrigation or to recharge acquifiers; identify risks and precautions; and

(k) itemize estimated costs at time of bidding.

Bidding. List of bids received and comment on procurement process.

Construction

Construction methodology, range of equipment employed and problems encountered, earthwork compaction control, need for and use of change orders; unit costs and total actual costs.

Operation

(a) start-up procedures and experiences; smell in early stages, etc.;

(b) staff and training; existence of organization and maintenance manuals;

(c) operational costs, labor, chemicals, equipment (including lawn mowing);

(d) pond performance monitoring system, existing and planned: parameters for monitoring, regulatory standards, overall effluent quality, smell reduction, sludge buildup, weed growth, evaporation, pond performance during cold weather, hydraulic flow through ponds and effect of wind and wave action; scum buildup; highlight any experiences in "recovering" the land used for a pond system; discuss opportunities for coping with enhanced flow or effluent change, and how to deal with isolated cases of overload; estimate degree of flexibility in pond design;

(e) implementing agency's reaction to ponds as a viable system;

(f) experiences in reuse of effluent; and

(g) need to "dose" final effluent, e.g. with chlorine; and discuss risks associated with chlorinated hydrocarbons.

Output

7. You will write a summary note on each of the ponding systems studied, identifying problem areas and, if appropriate, suggest remedial measures which you consider should be taken.

8. Based on your study findings and your own experience with ponding systems you will write a brief practical guideline on stabilization pond design and operation which will be of use to Bank project officers; providing inter alia:

(a) practical list of do's and dont's in pond location;

(b) rule of thumb formula which will give a feel for land requirements, function and number of ponds in a typical system (for a population range of 30,000-100,000), in typical LDC climates together with likely and recurring costs;

(c) civil engineering and earthwork guidelines;

(d) opportunities to expand the system with minimal additional earthworks;

(e) operational staff requirements and brief guidelines in the operation and maintenance of waste stabilization ponds;

(f) ancillary and effluent reuse possibilities;

(g) thresholds, land costs and other factors which may point to the need to study alternative treatment solutions; and

(h) comment on Israel's experience where a "kibbutz" has undertaken operation and maintenance of ponds in exchange for utilization of effluent.

9. The time allowed for this exercise is approximately 45 working or billable days, and the provisional travel schedule is as follows:

Date		Sites, Executing Agency, Remarks
May 12	Lv. Secondary Cities Philippines	
May 12	Arr. Manila	Dagat Dagatan Ponds, National Housing Authority
May 15	Lv. Manila	(in operation)
May 16	Arr. Calcutta, India	East Calcutta Area Development. CMDA integrated
May 19	Lv. Calcutta	scheme, fish farming and biogas. Initial earthworks completed. Design and construction review required
May 20	Arr. Tel Aviv, Israel	A large number of ponds constructed using Bank
May 30	Lv. Tel Aviv	finance. A vast experience of design, bidding, operational and effluent reuse. Streit, Israeli consultant, to join mission for 12 days
June 1	Arr. Nairobi, Kenya	Dandora Housing Project, Nairobi City Council
June 4	Lv. Nairobi	(in operation)
June 4	Arr. Lusaka, Zambia	Lusaka Squatter Upgrading Sites and Services
June 8	Lv. Lusaka	Project (in operation)
June 9	Arr. London, England	Report writing
June 18	Lv. London	
June 18	Arr. Washington, D.C.	Debriefing at World Bank, June 19
June 20	Lv. Washington, D.C.	
June 20	Arr. Kingston, Jamaica	Spanish Town Sites and Services Unit, Ministry
June 24	Lv. Kingston	of Housing (in operation)
June 27	Arr. Manila	
June 27	Lv. Manila	
June 27	Arr. Iloilo	

Contact names, offices and telephone numbers are enclosed.

Cleared with and cc: Messrs. Kalbermatten (TWT); MacWilliam (EMP); Gassner (EM2)

cc: Messrs. Rajagopalan (3) (PAS)
Churchill, Strombom, Dunkerley, Jones, Satin, Kahnert, Simmons, Cohen, Madavo, Johnson, H. Singh, Carr, Patel, Rathnam, Pellegrini, Jackson (URB) Buky (TWT); Sandstrom, Menezes, McCarthy (ASPUR) Serageldin, Assimakopoulos (EMPUR), Thys (EMP); Prevost (AEP) Sud, Ramani (AEPUW), Scott, Nassau, Canessa, Zuniga (LCPUR), Munthali (EA1) Godavitarne (ASPUR), Lilliehook (LAC); Deen (EA1); Hans Adler, Kraske, Bronfman (EMENA); Thalwitz, Geli (ASP) Choksi (AEA); Wiehen (ASA); Picciotto, Stewart, Bart, Gassner (EMENA); Kirmani, Golan, Jaycox, O'Brien (EAP); van der Meer, Wessels, Lari (LAC); Keare (2) DED; Southall (LEG)

DBCook:bcd

ANNEX B

STATUS OF POND SYSTEMS VISITED.

Following are brief statements on the status of the facilities visited. For those which are not operational, more detailed discussions of the reason for this are provided in the field notes.

B1. DAGAT DAGATAN, Manila, Philippines.
Aerated lagoon and polishing ponds not in operation due to minimal supply of sewage resulting from problems with the sewer main.

B2. EAST CALCUTTA, Calcutta, India.
Proposal to use a system of anaerobic facultative and maturation ponds to treat sewage now superceeded by recommendation to use biological filters. Effluent still to be used for fish ponds, the construction of which is completed.

B3. RAMAT HASHARON, Israel.
Aerated lagoons and polishing pond in operation.

B4. BET SHEMESH, Israel.
System of facultative and maturation ponds operational.

B5. RAMLE, Israel,
(i) Facultative ponds in parallel operating as facultative/anaerobic ponds.

MAAN, Israel.
(ii) Single maturation reservoir fed from Ramle ponds, in operation.

B6. LOD, Israel,
Aerated lagoons in operation.

B7. OR YEHUDA, Israel.
System of facultative and maturation ponds not operational due to overloading and operator's belief that treatment not necessary since effluent not used for irrigation. Sewage flows straight through plant to receiving stream.

B8. NETANYA, Israel.
Aerated lagoons, settling ponds and maturation ponds in operation.

B9. TEL MOND, Israel.
System of anaerobic, facultative and maturation ponds operational, with anaerobic units behaving as anaerobic/facultative ponds.

B10. SEDEROT, Israel.
System of anaerobic and facultative ponds plus maturation reservoir, in operation.

B11. YAVNEH, Israel.
Aerated lagoons in operation although full aeration capacity not required yet.

B12. ASHDOD, Israel.
System of anaerobic and facultative ponds only part operational, all ponds behave as anaerobic/facultative.

B13. EINSHEIMER, Israel.
System of anaerobic and facultative ponds in operation, anaerobic units operating as facultative ponds.

B14. MIGDAL HAEMEQ, Israel.
Single facultative pond cum reservoir in operation.

B15. NAZARETH, Israel.
Anaerobic cum facultative pond and maturation reservoir in operation.

B16. KARMIEL, Israel.
Anaerobic ponds and maturation reservoir in operation. One anaerobic pond being cleaned.

B17. SHELOMI, Israel.
Aerated lagoons and maturation reservoir. Due to percollation and aerator problems only one unit is in operation as an anaerobic pond.

B18. KIRIYATGAT Israel.
System of facultative ponds in operation but as facultative cum anaerobic ponds.

B19. OFAQIM, Israel.
System of anaerobic, facultative and maturation ponds. Only half system operated since average flow well below design flow.

B20. BEER SHEVA, Israel.
System of anaerobic, facultative and maturation ponds and reservoir. Half anaerobic ponds not being used to increase load on others and improve operation.

B21. ARAD, Israel.
System of anaerobic and facultative ponds with only half system operational since flow much less than design flow.

B22. EILAT, Israel.
Two aerated lagoons in operation, high rate pond not used due to rapid sludge building.

B23. DANDORA, Nairobi, Kenya.
System of facultative and maturation ponds in operation.

B24. DANDORA INDUSTRIAL ESTATE , Nairobi, Kenya.
System of facultative and maturation ponds in operation.

B25. MANCHICHI, Lusaka, Zambia.
Parallel system s of maturation ponds following biological filter plant, in operation.

B26. MATERO, Lusaka Zambia.
Three parallel systems of facultative and maturation ponds, in operation.

B27. NGWERERE, Lusaka, Zambia.
System of facultative and maturation ponds filling slowly due to few sewer connections, thus not yet fully operational.

B28. CHELSTON, Lusaka, Zambia.
System of facultative and maturation ponds in operation.

B29. MUNALI, Lusaka, Zambia.
System of facultative and maturation ponds in operation.

B30. DE LA VEGA, Spanish Town, Kingston, Jamaica.
System of facultative and maturation ponds in operation.

ANNEX C -

SUMMARY NOTES ON PONDS VISITED

C1. THE PHILIPPINES.
DAGAT DAGATAN AERATED LAGOON AND MATURATION PONDS, MANILA.

May 12th - 15th, 1981.

Client: National Housing Authority - Bank Financed.

1. Design.

a) There does not appear to have been any marked opposition to the use of ponds as a design solution. There were no preconceived ideas about the type of sewage treatment system to be employed since consideration of the treatment method coincided with planning for the whole Dagat Dagatan scheme. However, the client does appear to see the pond system as a temporary measure for use only until an interceptor is provided by the Metropolitan Waterworks and Sewerage System (MWSS) to take sewerage to a centralised treatment works. Although tentatively planned, there appears to be no definite programme for this project.

b) A wastewater treatment feasibility study was undertaken by J.M. Montgomery Consulting Engineersin 1978. This study considered five alternatives.

i) Completely mixed aerated lagoons with design based on a detention time of 4 days, and first order B.O.D.$_5$ removal.

ii) Aerated facultative lagoons (ie partially mixed aerated lagoons) again with an assumed detention time of 4 days and with design based on first order B.O.D.$_5$ removal. In this case oxygen requirements are based on that required for B.O.D.$_5$ removal rather than that required for complete mixing.

iii) Extended aeration activated sludge plant based on the stipulated B.O.D.$_5$ and S.S. removals (see table 1 below) and a mixed liquor suspended solids concentration of 1000 mg/l.

iv) Photosynthetic lagoons (i.e. facultative primary waste stabilisation pond) assuming a maximum permissible loading rate of 200 kg B.O.D.$_5$/ha/day.

v) Anaerobic pond followed by facultative pond based on an anaerobic pond loading rate of 0.125 kg B.O.D.$_5$/m^3/day and a facultative pond loading rate of 150 kg B.O.D.$_5$/ha/day.

Each of the five options also included provision of polishing ponds (i.e. maturation ponds), the design criteria of which are shown in table 2 below.

TABLE C1.1.1

Design assumptions for wastewater treatment alternatives.

Design Assumptions.	Phase I.	Final.
Contributing population	45,000	213,000
Flow rate	13.2 ml/d	53 ml/d
Waste water contribution	115 l/c/d	115 l/c/d
Industrial waste water contribution	150 kl/ha/d	150 kl/ha/d
Infiltration rate	50 kl/ha/d	50 kl/ha/d
$B.O.D._5$ domestic sewage	390 mg/l	390 mg/l
$B.O.D._5$ industrial effluent	390 mg/l	390 mg/l
Estimated wastewater $B.O.D._5$	290 mh/l	290 mg/l
Estimated wastewater S.S.	290 mg/l	290 mg/l
Effluent standard $B.O.D._5$	30 mg/l	30 mg/l
Effluent standard S.S.	50 mg/l	50 mg/l

TABLE C1.1.2

Design criteria for polishing ponds.

		Design Criteria.		
Primary Treatment Method	Deten. time	Influent $B.O.D._5$	BOD_5 remvl. rate constant	Areal BOD_5 loading rate.
1. Completely mixed aerated lagoon	4.5 days	9 mg/l	0.8	119 kg/ha/d
2. Partially mixed aerated lagoon	4.5 days	44 mg/l	0.8	182 kg/ha/d
3. Extended aeration activated sludge	4.5 days	30 mg/l	0.8	200 kg/ha/d
4. Facultative pond	7.7 days	85.7 mg/l	0.8	150 kg/ha/d
5. Anaerobic/facultative pond	3.1 days	55 mg/l	0.8	150 kg/ha/d

Considering four identical modules, the total area required for each alternative was calculated, and the corresponding capital and operational costs were estimated for one module only. However, the capital and operational costs of the two pond alternatives were not calculated. These systems were rejected without costs being considered because of the "unacceptably large area" of land required and in the case of the anaerobic facultative system the "potentially serious odour problems".

TABLE C1.1.3

Primary Treatment Method	Total area requirement	Capital cost 1 module	Annual operation and maintenance cost 1 module
1. Completely mixed aerated lagoon	18 ha	M₱ 6.4	₱ 166,150
2. Partially mixed aerated lagoon	20 ha	M₱ 4.6	₱ 166,050
3. Extended aeration activated sludge	14 ha	M₱ 14.4 or 6.1*	₱ 245,600
4. Facultative pond.	110 ha	?	?
5. Anaerobic/facultative pond	46 ha	?	?

* Package plant or earthen basin.

Critique.

Briefly -

i) Pond designs (options 4 and 5) were poorly carried out and calculations presented in the report are incomplete and ambiguous.

ii) Ponds designed at more realistic loading rates could have provided far more competitive designs. Very provisional calculations show 42ha for option 4 (compare 110ha) and 31 ha for option 5 (compare 46 ha).

iii) No consideration is given to any weighting in favour of methods using little or no mechanical plant to reflect the reduced probability of mechanical breakdown.

iv) Weighting is also not considered in favour of methods with cheaper annual operation and maintenance costs, pond systems would undoubtedly provide cheaper operation and maintenance costs.

On the basis of the J. M. Montgomery feasibility study the partially unmixed aerated lagoon was selected by the National Housing Authority (N.H.A.) as the preferred alternative. The first module comprised the following:-

i) Aerated lagoon of 3m liquid depth, 1.5ha liquid surface area and 4 day detention time with 9 no. 25hp aerators, freeboard 0.9m.

ii) Polishing pond of 2.0m liquid depth, 3.2 ha liquid surface area and a 4.5 day detention time, freeboard 0.6m.

In response to comments made by Roy Ramani of I.B.R.D. in 1977 the following changes were made:-

i) Estimated final design flow was reduced from 53 ml/day to 39 ml/day, thus three rather than four 13 ml/day modules would be required.

ii) Due to this reduced flow rate the initial pond series would be able to serve more than the phase I and phase IIA development which would now provide only 11.1 ml/day.

iii) Use of only 6 no. 25 hp. aerators per aerated lagoon was recommended to satisfy aeration requirements and provide a minimum velocity of $0.3ms^{-1}$ at least for the intial stage.

iv) The single 3.5 ha polishing pond was split to give a secondary 2ha pond and a tertiary 1.5ha pond to provide better treatment. The total pond surface area was thus slightly reduced.

Design of the additional modules required to treat the effluent from the remaining development is currently being considered. Kinhill engineers, Consultants to the N.H.A. for Dagat Dagatan have produced a design brief which lists the extent of work as,

i) Provision of additional treatment modules based on the existing module and in number not expected to be below two or above three.

ii) Additional pumps to be installed in the existing pumping station.

iii) Chlorination of the effluent from both these proposed modules and the existing module.

iv) Related works including connection of rising mains, security fencing, roadways etc.,

The design parameters for the proposed modules are as follows:-

	Area of land available	13 ha.
	Average sewage strength	300 mg/l BOD_5
	No. of modules	2 or 3
Aerated	Regime	completely mixed
Lagoons:	Detention time	4 days
	Depth	max. allowable.
	Aerators	4 no. per lagoon.
Polishing	Detention time	4-5 days
ponds:	Depth	2m plus storage
	Sludge storage	sufficient for 5 years
Chlorin-	Contact time	60 minutes
ation:	Maximum dose rate	15 mg/l.

This design brief is currently being reviewed by N.H.A.

The following comments are made in response to specific points raised in the terms of reference.

i) Evaporation and percolation forecasts:
The critical period for evaporation is April during which the average is 6mm/day. Percolation forecasts were not made, presumably in view of the intention to line the ponds with clay, which should render percollation negligible.

ii) Procedures for dealing with temperature variation and prolonged cold periods:
In the case of the Dagat Dagatan ponds where the minimum monthly average temperature is about 30°C, these problems do not arise.

iii) The capacity of the pond system to cope with industrial effluents was not given special consideration in the design. This is in spite of the predicted industrial effluent comprising 30% of the total sewage flow and being equal to 60% of the domestic contribution. The BOD_5 of the industrial effluent is assumed to be the same as that of the domestic sewage and equal to 300 mg/l.

c) The ponds are constructed on a reclaimed area and because of bad reclamation practice the soil varies considerably within the surface layer from a coarse sand to a fine silty clay. The embankments were constructed using selected excavated material together with suitable embankment material (silty clays) brought from off the site ,95% compaction was specified, and the degree of compaction achieved was continually monitored during embankment construction. A clay blanket minimum thickness 40 cm. was rolled onto the interior embankments and onto the pond floor to a distance of 10m from the embankment toe. Rip rap is provided as an erosion protection in the aerated lagoon extending 1 meter above and below the proposed water level. No edge protection is provided for the two polishing ponds.

The fact that the ponds filled with water during the 1980 rainy season as the water table rose, indicates that particularly during the dry season, percolation from the ponds may be a problem. The interpond connections comprise single pipes with weir boxes. These provide level control at the effluent points from the aerated lagoon and final polishing pond. The aerated lagoon has dual submerged inlets 50m apart which discharge one quarter of the way into the pond. The outlets are 1m above the pond floor and point vertically upwards. In the polishing ponds the inlet and outlet pipes are positioned opposite one another.

Although the weirs provided at the outlets to the aerated lagoon and final polishing pond could be used for flow measurement, there is no purpose built flow measuring device at the inlet to the pond system. Preliminary treatment in the form of a bar screen and comminutor is provided at the inlet to the pumping station. A bypass is provided to facilitate the cleaning of the primary and secondary ponds when this becomes necessary.

d) The fencing comprises a 1.8m high chain link fence with 2" mesh plus 3 strands of galvanised steel wire with 4 point barbs. The total height is 2m. The fence is supported by 3" outside diameter galvanised pipe with the top 30cm bent over at 45° for the barbed wire. The posts are approximately 5m apart and bedded in 90cm deep concrete foundations. In addition 5 guard huts have been constructed on the site and the guard is maintained 24 hours a day.

e) Because the ponds are empty, grass and scrub is growing both inside and outside the ponds. Growth is controlled by the maintenance staff but plants taking root on the outside embankments should be kept to help prevent embankment erosion. Access for vehicles to and around the ponds is good, and the embankments are surfaced with crushed rock.

f) Security lighting is provided with 6m high lamp posts just inside the security fence at approximately 60metre intervals. The posts are of tubular steel with the lights cantilevered out at 2m from the post. Mercury lamps of 250 watts (220v) with wire guards are provided.

g) A blockwork laboratory and office building is provided with approximately 30 sq.m. of laboratory space. The equipment either already in place or to be delivered shortly includes:- Spectrophotometer, Auto Sampler, Autoclave, Incubator, Refrigerator, pH meter, microscope plus other equipment sophisticated enough to allow quite extensive research to be carried out at the laboratory.

h) Net area of ponds 5.2ha.
Gross area of site 7.6 ha.
Land reserved for future expansion 13ha.

In siting the ponds attention appears to have been given to factors such as prevailing wind direction, proximity to residential areas and proximity to disposal site. Where land is expensive and in short supply it is inevitable that the sewage treatment works will be sited closer to residential areas than would otherwise be desirable. However, this distance can be increased by planning an industrial or commercial buffer zone between the plant and the housing as is planned in this case.

i) Ancillary uses such as algal harvesting or algal utilisation through fish farming have not been considered.

j) No effluent reuse is proposed in this case. In view of the lack of suitable land for irrigation within a reasonable distance of the ponds, reuse for irrigation seems impractical. Furthermore, the close proximity of the water table to the ground surface suggest that groundwater recharge is equally infeasible. In the circumstances discharge to the creek seems the simplest solution.

k) Estimated costs at time of bidding.

	₱		US$
Mobilisation	460,000		
Excavation	1,295,000		
Embankment construction	2,850,626		
Buildings	60,129		
Interpond connections	270,115		
Aerators	30,732	plus	78,167
Electrical	427,584		
Fencing	287,283		
Force main	1,586,400		
Pump station	826,037	plus	4,800
Piles	145,296	plus	37,703
	8,239,196		120,670
Totals without force main and pump station.	5,826,759	plus	115,870

2. <u>Bidding</u>.
The bidding was held in Tondo on 2nd November 1977. There were 5 bidders of which one was disqualified for non compliance, all had to prequalify.

At this time the total government estimate was,	P 8,880,096
The bids were,	
Dimson Manila	P 10,036,750
Concept Builders Inc.	P 9,373,296
Carcencho construction	P 9,669,610
Weldon Construction	P 10,224,978

The lowest bidder was chosen. Dimsons were already known to the N.H.A. and had performed satisfactorily on several previous N.H.A. projects.

3. Construction

Methodology employed in construction was basically clearing and grubbing of site, excavation of ponds and use of selected excavated material along with clays brought onto the site for embankment construction.

Embankments were constructed by over excavation to a maximum of 0.5m below existing ground level, backfilling with compacted non plastic fill material (no more than 20% passing No. 200 sieve), and construction in 200mm layers compacted to 95% density with sheepsfoot rollers. Every layer was tested for compaction using an 18 inch drop for a 10lb hammer. Finally the clay embankment liner was added.

Mechanical equipment employed in construction was mainly medium or heavy earth moving equipment e.g. D7 bulldozers, sheepsfoot rollers, and towards the end, graders. The final value of the completed contract was,

P 13,504,501.33

This sum included change orders brought about by the decision to divide the proposed single polishing pond into two units. The total value of the change orders was,

P 2,746,598.28

Assuming a population equivalent served of 113,000 (115 l/c/d) the cost per capita of the system is,

P 120 or about $16 at current exchange rates.

or excluding the industry and considering only the 70,000 actually served the cost per capita is,

P 193 or about $25 per capita at current exchange rates.

These costs exclude land, but include the pumping station and rising main.

4. Operation

a) There is no plan to use any special start up procedures for the aerated lagoon or polishing ponds. It is likely that the slow increase in hydraulic and organic loading rates on the system, resulting from progressive additional connection to the sewerage system, should in itself provide an adequately gradual start up. Since only small amounts of wastewater have so far found their way into the ponds, no nuisance has been experienced as yet.

b) The operational staff of the plant number 15 in all and comprise the following:-

1 Project Supervisor.
2 Environmental Engineers.
1 Mechanical Engineer.
2 Laboratory technicians.
1 Plant operator.
1 Pump operator.
1 Secretary
1 Driver
and 5 Labourers.

There are also 4 security men.
Of these the professional staff have all received special training, A total of four staff attended a special 2 month course on the operation and maintenance of aerated lagoon systems run by J.M. Montgomery in the U.S.A. The operators are in possession of maintenance manuals provided as part of this course.

There is a plan for the Metropolitan Waterworks and Sewerage System (MWSS) to take over operation and maintenance of the plant almost immediately. If this does occur, the staff trained specifically for the operation of this system will be replaced by MWSS staff who are untrained.

c) The predicted operational costs for 1981 excluding wages (ie basically power consumption plus some chemicals was, P 588,000. To this could probably be added P150,000 for wages, giving a total operational and maintenance cost of about ₱738,000 for 1981.

d) There is a proposed monitoring system based on regular measurements of B.O.D.$_5$, suspended and total solids, pH and other physical and chemical parameters. The monitoring of pond performance should include some bacterial measurement, preferably of Faecal Coliforms or Eshericlia Coli even though faecal bacterial concentration is not a stipulation for effluent quality. The stipulated standards for discharge into a receiving stream such as the one into which the Dagat Dagatan ponds will discharge is 30 mg/l B.O.D.$_5$ and 50 mg/l S.S. The pond system is predicted to be able to achieve this standard with a suspended solids of 47 mg/l and BOD_5 of 33 mg/l (slightly more than standard) in the final effluent. The figure for effluent BOD_5 assumes a soluable BOD_5 removal rate constant of 0.8 and that the total BOD_5 is equal to the sum of the soluable BOD_5 plus half the effluent suspended solids concentration.

There are no special provisions for coping with enhanced flow or effluent change from the pond system. Once the design load has been achieved, cases of overloading could be controlled by the addition of further aerators to the primary pond. However, with a detention time of only 3 days in the second pond problems of overloading could also occur in this unit, which is too shallow to allow use of powerful aerators. Thus the pond system as it stands is not particularly flexible, although with the provision of further modules this flexibility is likely to increase.

e) The implementing agency is happy with the pond system as a solution, but since the system has not yet been fully commissioned, their reaction to the systems operation has yet to be assessed.

f) There are no plans to reuse the effluent, nor does there appear to be a ready demand for the effluent since there is no agricultural land adjacent to the system.

g) The original design report did propose effluent chlorination but no chlorination equipment has been installed to date. The design brief for Phase II of the treatment works also recommends chlorination at a maximum dosing rate of 15 mg/l and with a 60 minute contact time. Quite apart from any risks associated with chlorinated hydrocarbons, the other factors which effect chlorination efficiency mentioned in the main body of the report should also be considered. In this case it is particularly important to compare the bacteriological quality of the sewage effluent to that of the receiving stream before chlorination is even considered.

5. Status and Problems.

The Dagat Dagatan pond system is not operational for the following reasons.

i) Main interceptor C3 serving Phase I development and discharging to the ponds has been poorly laid with many pipe sections considerably out of line, resulting in an estimated 2.3 million litres per day of infiltration into the pipe during the rainy season.

ii) The original contractor has refused to return to site and correct this work so a new contractor has been engaged to carry out the work which involves relaying two sections of the sewer, each of about 100m length.

iii) The sewage from Phase I development which should flow through this sewer to the ponds is being pumped into a temporary septic tank and thence into an adjacent creek.

iv) Sewage from the parts of Phase II already sewered plus infiltration water is being pumped into the aerated lagoon. However, there is sufficient sewage only for the pumps to be operated for a period of about 10 minutes twice a day. Thus infiltration into the pipe is currently very low, possibly as a result of a lowering of the water table during the dry season.

6. Remedial Measures.

i) Rather than the sewage from Phase I development being pumped into a temporary septic tank, the sewage should be allowed to flow down the sections of the C3 main which are not to be relaid. Those sections which are to be relaid may then be bypassed by pumping through flexible pipes laid on the surface between adjacent manholes, using submersible sewage pump(s). This will enable full commissioning of the pond system as soon as possible.

ii) Once the system is fully operational and equilibrium has been attained, monitoring of operation and the degree of treatment achieved will enable this information to be used in the detailed design of the second and third modules.

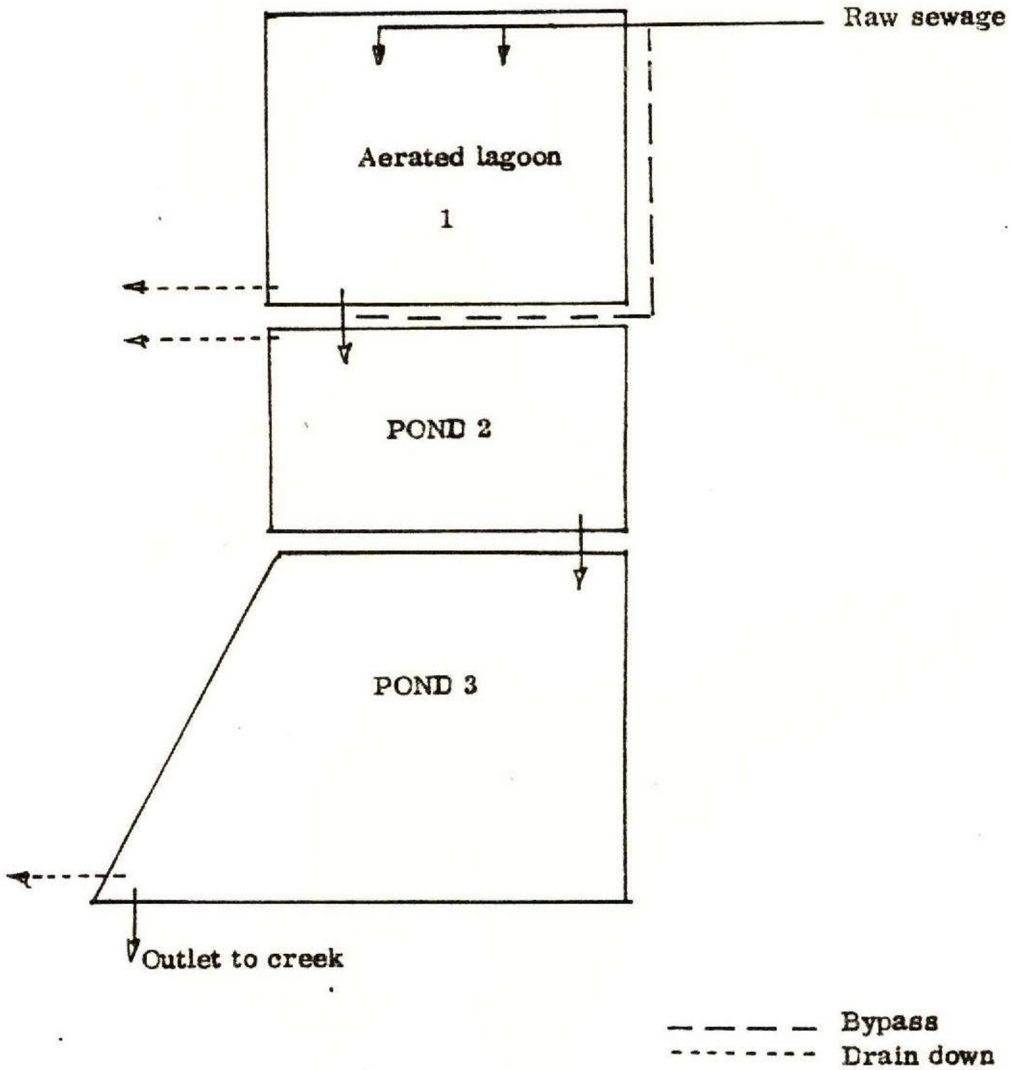
iii) The necessary laboratory equipment to enable bacterial counts for either faecal coliforms or E.Coli (preferably membrane filtration equipment if available) should be obtained. This will permit bacterial die off through the pond system to be monitored,as well as the bacteriological quality of the final effluent and receiving stream.

iv) Whilst the polishing ponds remain empty the opportunity should be taken to make some improvements as follows:-

a) Remove all remaining vegetation growing inside the ponds.
b) Check that where vegetation is removed from the internal embankments the clay lining has not been punctured. Where this has occured make good.
c) Provision of rip rap wave protection around the polishing pond periphery at water level to avoid erosion problems,and simplify embankment maintenance. A similar design to that used in the aerated lagoons would be satisfactory.

DAGAT DAGATAN - SCHEMATIC DIAGRAM

Not to scale



C2. ISRAEL.

C2.1 GENERAL CONCLUSIONS FROM THE POND SYSTEMS VISITED IN ISRAEL. MAY 20th - 31st, 1981.

1.1 Design

a) Client municipalities or local authorities in Israel sometimes have objections to the use of pond systems for sewage treatment. These objections are generally based on,

i) Belief that odour problems will occur.
ii) Problems finding available land which isn't expensive.

These problems are frequently resolved by finding a market for the effluent. The land required for the pond system may then be provided by a kibbutz, moshave, or farmer in exchange for use of the effluent.

b) Although the design of pond systems varies considerably between one consultant and another, pond systems in Israel are invariably designed on the basis of empirical loadings and/or detention times. The basis of these designs is often loading rates similar to those set out in "A Comprehensive Plan for Sewerage in Israel. Basic Data and Background Material for IBRD Mission" July 1971. This document recommends:

i) Anaerobic ponds - 100 to 350 kg BOD_5 per dunam per day (1000 to 3500 kg BOD_5/ha/day), and detention time $\nless$ 2 days. Depth 2.5m to 4m.

ii) Facultative ponds - $<$ 20 kg BOD_5 per dunam per day ($<$ 200 kg BOD_5 /ha/day), detention time $>$ 20 days if secondary unit or 35 days if primary unit. Depth 1m to 1.5m.

iii) Maturation ponds $<$ 12 kg BOD_5 per dunam per day ($<$ 120 kg BOD_5/ha/day), detention time $>$ 20 days, depth 1m to 1.5m.

Although there are climatic variations within Israel, these are fairly small, and in most places the minimum monthly average temperature is within a degree or two of $14^{o}C$. At none of the sites visited (with the exception of Eilat $-18^{o}C$) was the minimum mean monthly average temperature less than $12^{o}C$ or more than $15^{o}C$.

Where reuse of the effluent has been a major consideration in design, the treatment system itself is often tailored to suit the irrigation needs. Frequently secondary or tertiary treatment is provided by a large reservoir, the detention time of which may be 100 days or more up to the beginning of the irrigation season but only a few days at the end of the season when the reservoir is empty.

The design of aerated lagoons is also based largely on empirical detention times and power per unit volume. Most of designs relate to facultative or partially mixed aerated lagoons, and where rational design approaches are considered the Eckenfelder equations are generally used. Most designs seem to comply with the detention times and power rates given in the July 1971 report for the IBRD mission, on the comprehensive plan for sewerage in Israel. These are given below:

i) Completely mixed aerated lagoons, 20 watts per cubic meter of pond volume.

ii) Partially mixed aerated lagoons 3 to 4 watts per cubic meter of pond volume.

iii) The detention time is normally calculated on the basis of an assumed BOD_5 removal rate constant, and according to the Eckenfelder equation for first order BOD_5 removal in aerated lagoons. Thus a lagoon may be designed for a particular BOD_5 removal although generally a detention time of 4 days is used in primary partially mixed aerated lagoons. A depth of between 1.8 and 5 metres is recommended, depending on the type of aerators used.

iv) The aerated lagoons visited in Israel were serving populations of between 2,600 (Shelomi), and 100,000 (Netanya). Compared to populations of between 3,500 (Tel Mond) and 110,000 (Beer Sheeva) for the pond systems visited. The temperature variations at all the lagoon and pond systems visited were similar, varying between a minimum mean monthly temperature of about 13°C and a maximum mean monthly temperature of about 28°C.

c) As the soil conditions vary across the country, so does the need to provide ponds with a lining. However, few of the systems visited were lined and few were provided with any form of wave protection at the waters edge. As a result of this, many of the systems showed signs of embankment erosion and many had embankments covered in lush vegetation often growing down into the ponds.

Inlet and outlet structures varied in design but few installations were provided with flow measuring devices, and of those that were, most of the venture flume type were not working.

d) Fencing type varies, but all plants visited were, or had originally been, fenced. In some installations the fencing was greatly in need of repair.

e) In none of the facilities visited had landscaping as such been carried out, although vegetation was generally covering the outside embankments of pond systems thus aiding embankment stability, and helping prevent erosion.

f) In none of the plants visited was lighting provided except in the office building (if any) and/or at the main entrance.

g) In only one of the treatment plants visited were there laboratory facilities at the plant. Most of the pond systems were too small to justify inclusion of laboratory facilities on site.

h) Site selection in Israel is predominantly a question of where land can be found, such land is generally owned by a farmer or kibbutz and the site is invariably chosen at some distance from the nearest residential area.

i) None of the systems visited included ancillary use for fish farming or any other methods of algal utilisation. It was noticeable that many of the systems - particularly those where maintenance was seldom carried out, served as bird sanctuaries and nests complete with eggs were frequently encountered whilst walking along the embankments. The Israeli Ministry of Health will only allow fish farming using sewage effluent when primary treatment has been carried out by aerated lagoon. The reasons for this restriction are not clear since pathogenic bacteria and helminths are more likely to be carried over into a secondary pond from an aerated lagoon than from a primary waste stabilisation pond. This is because the main means by which helminthic ova, cysts and eggs are removed from raw sewage is by settlement under quiescent conditions. Such conditions are experienced in anaerobic and facultative ponds, but not in aerated lagoons where the mechanical agitation of the lagoon contents is likely to prevent ova, cysts and eggs from settling out, enabling them to pass over into subsequent ponds. Bacterial removal on the other hand is largely a function of detention time. Thus a facultative primary pond is likely to provide a greater degree of bacterial removal than either an aerated lagoon or anaerobic pond, both of which have shorter detention times.

j) In almost every case the effluent from the pond systems visited was used for irrigation. Most of this irrigation was carried out by the kibbutzim using spray irrigation usually of cotton or fodder crops. In many cases the effluent being used was not of a quality generally recommended for spray irrigation according to W.H.O. standards. Table C2.1 shows the water quality guidelines used in Israel for irrigation waters, although in individual cases the use of a certain effluent for irrigation of a particular crop may be agreed by the Ministry of Health even though the criteria in Table C2.1 may not be satisfied.

In general terms the Ministry of Agriculture fights to get irrigation standards lowered whilst the Ministry of of Health fights to maintain the quality criteria for irrigation water which they think necessary. Re-use by the recharging of acquifiers is generally not practised in Israel. Indeed, in areas where acquifiers are used for the water supply restrictions on effluent discharge are particularly strict, and in some cases release of effluent to the land or dry water courses is not permitted.

The exception to this is the Dan region project which is a highly technically advanced wastewater treatment system aimed at producing an effluent suitable for groundwater recharge. This system does include polishing ponds which are specifically designed for ammonia stripping and natural recarbonation.

k) Itemised costs at the time of bidding were not available for most of the pond systems visited.

1.2 Bidding

It proved both difficult and probably unnecessary to obtain lists of the bids received for each of the pond systems visited. No particular problems have been experienced in the bidding and procuring of contractors for pond system construction.

Many contractors in Israel are experienced in pond construction and have to be registered to bid for a pond system construction. Because of this registration Israeli contractors do have to prequalify before they can tender. Procurement is through tender only and it is unusual for the lowest bid to be rejected.

TABLE C2.1 SUMMARY OF PROPOSED CRITERIA FOR QUALITY OF TREATED WASTEWATER EFFLUENT TO BE USED FOR IRRIGATION

Group of crops	A	B	C	D
Principal crops	Cotton, sugar beet cereals, dry fodder seeds, forest irrigation	Green fodder, olives. peanuts, citrus, bananas, almonds, nuts, etc.	Deciduous fruits[2], conserved vegetables, cooked vegetables, peeled vegetables, green belts, football fields and golf courses	Unrestricted crops, parks and lawns
Effluent Quality (should not be surpassed in more than 20% of the samples tested)				
BOD, total, mg/l	[1]60	[1]45	35	15
BOD, dissolved, mg/l	-	-	20	10
Suspended solids, mg/l	50	40	30	15
Dissolved oxygen, mg/l	0.5	0.5	0.5	0.5
Coliform counts/100 ml	-	-	250	12 (80%) 2.2(50%)
Residual available chlorine,mg/l	-	-	0.15	0.5
Mandatory treatment				
Sand filtration[3]	-	-	-	required
Chlorination, minimum contact time, minutes	-	-	60	120
Distances				
From residential areas, m	300	250	-	-
From paved road, m	30	25	-	-

[1]Different stadnards will be set for stabilization ponds with retention time of at least 15 days.

[2]Irrigation mUst stop two weeks before fruit picking;no fruit should be picked from the ground.

[3]Sand filtration or equivalent treatment with respect to effluent quality and operational reliability.

If this does occur then reasons must be given by the tender board - normally largely made up of people from the client municipality. All contracts for projects which are bank funded comply with the IBRD standard contract plus Israeli law on contracts. The system appears to work well since contractual problems during construction did not occur on any of the projects visited.

1.3 Construction.

Construction methods for each of the systems visited were similar with some variation to account for differences in terrain and soil. Embankment construction followed the same pattern in every case with sheepsfoot roller and/or vibration compaction of selected material in maximum 200mm layers. Use of impermeable clay embankment core or clay lining of pond depended on suitability of excavated material for embankment construction, and anticipated percolation.

Data on unit costs was not generally available although total actual costs were obtained for some of the systems visited. Change orders were necessary on a number of the projects, but the increased costs generally fell within that allowed for contingencies. There are particular problems in dealing with the costs from Israel because of the high inflation rate currently running at about 130% per annum. However, attempts have been made to bring the costs to a common base.

1.4 Operation.

a) There are no special start up procedures used in Israel although in most cases the ponds were commissioned during the summer. This avoids starting up in the winter when the temperature may have a detrimental effect on the ability of the microorganisms to become established rapidly. None of the systems reviewed suffered any particular problems during start up, although as would be expected, the percolation rate is very high initially. No particular smell problems were reported in the early stages of operation.

b) Most of the operational staff of the pond systems reviewed fell into one of two categories:

   i) Employees of Mekorot, the national water company, who are in a number of cases employed by the local authority to maintain and operate the larger pond systems.

   ii) Kibbutz members or employees of farmers who spend part of their time maintaining the pond systems from which they take the effluent.

The former of these two groups look after most of the aerated lagoons visited and tend to be equipment maintainers rather than pond system maintainers. There are no maintenance manuals for the ponds themselves, but there is information on the maintenance of the mechanical equipment. The training system involves learning on the job, and Mekorot does have the advantage of experience in the field of pond system maintenance.

The second group do not have any training, nor do they have operation or maintenance manuals. Often part of the agreement between a kibbutz and a municipality or local authority is that the kibbutz is responsible for maintaining the system in exchange for use of the effluent. There are certain problems associated with this system since the major requirement as far as the kibbutz is concerned is to maintain the supply of irrigation water. Achieving a regular supply of effluent need not necessarily depend on the physical condition of the ponds, and need take no account of effluent quality. These problems are discussed in more detail below.

c) Operational costs were obtained for some of the systems reviewed. However, for many of the smaller systems costs are difficult to estimate, since they are operated by unpaid kibbutz workers and may only require a few gallons of weedkiller and insecticide every couple of months.

d) Only one of the treatment plants visited has a system of regular monitoring of performance. No treatment data or effluent quality data was available for most of the pond systems. Monitoring of effluents used for irrigation was not carried out, although there are stipulated quality criteria as shown in Table C2.1.

A number of systems visited were overloaded and odour problems were being encountered. Remedial actions to reduce the odour problems were being taken in some cases. These actions generally take the form of,

i) Provision of surface aerators to maintain some dissolved oxygen at the surface.

ii) Recirculation of the effluent to the inlet,again to introduce some oxygen into the primary unit.

iii) Adjustment of loading rates to ensure ponds operate either as anaerobic or facultative units.

Sludge build up was on the whole found to correspond to about $0.05m^3$ per capita per annum in primary units for pond systems treating domestic sewage only. Some systems treating significant quantities of industrial effluent were found to suffer a more frequent build up of sludge. In a number of the systems visited desludging had been carried out without major problems. However, contractors were found often to underestimate the quantities of sludge to be removed. In most cases desluding of primary anaerobic ponds was found to be necessary after a period of about 10 years. This can be reduced to as little as 5 years where effluents from industries producing large amounts of solids are treated, or increased to as much as 15 years where domestic sewage only is treated

Weed growth was observed in many of the pond systems visited, although growth of vegetation from the main body of the ponds was never observed. Growth of eeds in particular at and below the water level on the embankments was very common where no hard water edge protection was used.

Evaporation was found to be a problem only in as much as it reduced the quantity of water available for irrigation. Thus there was a tendancy for the Kibbutzim to reduce to a minimum the time that potential irrigation water was exposed to evaporation in the pond system, and/or to build deep reservoirs.

It was difficult to establish whether pond performance suffered during cold weather because of the lack of performance data. However, for a number of the systems visited a reduction in algal concentration and colour changes were observed during the winter. Where overloaded units were causing odour problems no change was observed in the intensity of the problem between winter and summer. Furthermore, none of the systems visited which were operating satisfactorily were said to suffer from odour problems during the winter.

Since there was no data available from any of the systems visited on pond mixing it was difficult to assess what effects the wind had on this aspect. Several of the systems with large pond areas and no embankment protection at water level were found to be suffering from severe erosion problems.

In none of the systems visited had land been recovered for other uses.

Of the systems visited which were running at hydraulic and organic loading rates equal to or greater than the design capacity, the flexibility of the system to deal with overloading or effluent change was strictly limited. Where only part of the pond system was in use due to flows well below the ultimate design flow, or where the systems was in full use but at low loading rates, hydraulic or organic overloading could be handled by operating additional units or could be absorbed by the underloaded pond systems.

e) The reaction of the implementing agency to pond systems was in most cases one of satisfaction. The advantages of simple maintenance and cheap operation make ponds particularly popular. Only where overloading had caused odour problems was there any adverse reaction, and in most cases the ponds were far enough away from residential areas for this to cause no nuisance problem.

f) Experience in effluent reuse in Israel is considerable and in nearly all the pond systems visited the effluent was being used for irrigation. The system was usually that in exchange for use of the effluent the kibbutz (or moshave or farmer) would provide land for the treatment system and operate and maintain the plant. Because of the necessity of irrigating the crops the system is looked upon by the kibbutz more as a water management system than a wastewater treatment system. As a result there is a tendancy to ignore the operation and maintenance of the waste stabilisation pond system until it adversely effects the efficiency of the irrigation operation.

Depending on the crop irrigated, the reuse system is geared to achieve maximum reuse of the effluent. In the case of the most frequently irrigated crop - cotton- this means construction of a large reservoir(ideally of a volume sufficienct to contain about 9 months of pond effluent)which is applied to the cotton during the irrigation season which in most parts of the country means from June until August. For other crops, such as fruit trees, the irrigation is carried on during most of the year and there is thus no need for a reservoir. In this case irrigation water is drawn directly from the final pond in the pond series.

g) In none of the pond systems visited was chlorination of the final effluent undertaken. Research has been carried out in Israel to show that Chlorination of the effluents could be undertaken should the need arise or legislation be introduced. However, there are problems associated with chlorination of waste stabilisation ponds effluents some of which are,

i) Chlorinated hydrocarbons, the risks associated with which are currently not fully understood.

ii) The large amount of chlorine required to produce a free chlorine residual in waste stabilisation pond effluents due to its absorption by organics (2mg/l chlorine is required to absorb 1 mg/l BOD_5).

iii) The effectiveness of chlorination in reducing numbers of pathogenic bacteria in effluents is questionable. Bacterial aftergrowth has been shown to occur with faecal coliforms in chlorinated effluents.

iv) Where effluents are discharged to receiving streams it is often the case that without chlorination the bacteriological quality of the sewage effluent is better than that of the receiving stream.

C2.2 RAMAT HASHARON, ISRAEL

Client: Local Council, Bank Funded. May 21st.

2.1 Design.

a) No resistance to use of ponds.

b) Design based on empirical design criteria for aerated lagoons.

Design Parameters.

Population	50,000 for 1985
Per capita wastewater contribution	190 l/c/d
Daily average wastewater flow	10,800 m^3/day
Per capita BOD_5 contribution	65 g/capita.
BOD_5 mg/l	294 mg/l
BOD_5 kg/day	3,175 kg.

System designed was two aerated lagoons in series and one polishing pond as a rehabilitation and extension of an existing waste stabilisation pond system. As no further land available aerators had to be used to keep effluent standard up.

Pond Characteristics (Design).

		Aerated lagoon 1	Aerated lagoon 2	Polishing Pond.
Volume	m^3	12,700	12,700	85.500
Depth	m	3	3	3.3
Freeboard	m	0.8	0.8	0.8
Surface area	ha	0.535	0.535	2.91
Side slope		1:3	1:3	1:3
Detention time	days	3.2	3.2	21
Aerators	Hp	2 x 30 Hp	2 x 15 Hp	
Power supplied		3.5w/m^3	1.75w/m^3	

Design loading rates were,

	Lagoon 1	Lagoon 2	Polishing Pond.
Volumetric	0.106 kg/m^3/day	0.043 kg/m^3/day	
Areal	2520 kg/ha/day	1000 kg/ha/day	135 kg/ha/day*

* This assumes 90% total BOD_5 removal.

c) The soil is a silty clay and this was used in embankment construction, no extra material was brought onto site. No percollation problems have been experienced although the ponds were not lined.

No embankment protection has been provided, and erosion is occuring, particularly in the aerated lagoons at water level.

The interpond connections are via simple pipes with submerged inlets and outlets. Water level is controlled through pumping or overflow from the polishing pond.

Preliminary treatment did not exist until recently when an automatically cleaned screen was added to prevent large solids reaching the ponds and fouling the aerators. This unit is still suffering operational problems and has not operated satisfactorily as yet. There is a V notch flow measuring device between the first and second ponds, but nothing at the inlet to measure the flow.

A bypass enables the primary pond to be bypassed and raw sewage to flow to the secondary pond, or the plant to be completely bypassed and raw sewage flow to the Yarkan river.

d) The fencing comprises 1.5m high chain link with 3 strands of barbed wire above it. The fencing was broken in a number of places.

e) No landscaping was provided, although grass is growing on the embankments and the outside slopes. Road access to the plant was poor and there is no vehicular access around the ponds.

f) No lighting was provided.

g) There are no laboratory facilities.

h) The net area of the ponds is 4.0ha.
The gross area of the site is 4.6ha.
There is no reserved land.
The land is within the municipal boundary and is thus owned by the local council. The site is approximately 1km from the nearest residential neighbourhood and 0.4km from the nearest main road.

i) No ancillary uses of the ponds are practiced.

j) For 7 to 8 months of the year the effluent is reused for irrigation of citrus groves. The irrigation water is taken from the polishing pond and about 800 ha. of land is irrigated. A tertiary treatment horizontal rock filter is used before the effluent is pumped for irrigation and the pumping station is owned by the municipality who charge 2.5 US cents per m^3 for the 800,000 m^2 of irrigation water used per season. (a very low rate). During the remaining 4-5 months of the year the effluent overflows to the Yarkan river.

k) Costs at the time of bidding were not available.

2.2 Bidding.

A list of the bids received was not readily available. Procurement was by the usual process, the lowest bid being taken, and the tendering firms being either registered or prequalified.

2.3 Construction.

Usual construction methods were employed using normal earth moving and compaction equipment.

Following is a breakdown of the capital costs for the 1975 extension and rehabilitation of the works, with costs in US$ at October 1980 prices.

Civil works	400,000 US$	73.5%
Mechanical equipment and power connections	80,000 US$	14.7%
Engineering services	64,000 US$	11.8%
	544,000 US$	

Assuming that the increased treatment capacity serves an additional 18,000 people, the cost per capita is US$ 30.

There was a need for change orders on this project and cost over runs of about 15% on the total contract price were incurred. This was largely due to problems of estimating the costs for cleaning the pre existing anaerobic ponds, and clearing the area for the increased size of polishing ponds. The overrrun in the civil works was around 20% but was covered by the contingencies included in the contract.

2.4 Operation.

a) No special start up procedures were used, and no smell was experienced in the early stages.

b) No staff training was undertaken and no organisation or maintenance manuals exist. Six men look after the town sewers and treatment plant.

c) No data was available for the operational costs although the income from the sale of the effluent is greater than the maintenance budget both for the maintenance of the pond system and the municipal sewerage system. Major items of cost are wages, power consumption and chemicals for weed and insect spraying which is regularly carried out.

d) There is no pond monitoring system. A survey was carried out in 1978 which gave the following data.

Population	31,000
Per capita wastewater contribution	143 mg/l
Daily average wastewater flow	4,000 m^3/day
Per capita BOD_5 contribution	50 g/capita.
BOD_5 of raw sewage	280 mg/l
BOD_5 loading	1120 kg/day

Assuming for 1981 the following data.

Per capita wastewater contribution	143 mg/l
Daily average wastewater flow	5000 m^3/day
per capita BOD_5 contribution	60 g/capita.
BOD_5 of raw sewage	315 mg/l
BOD_5 loading	1575 kg/day.

The actual loading rates are,

	Lagoon 1	Lagoon 2	Polishing Pond.
Volumetric	0.124 kg/m^3/day	0.66 kg/m^3/day	
Areal	2940 kg/ha/day	1560 kg/ha/day	173 kg/ha/day
Detention Time	2.5 days	2.5 days	17 days.

Assuming the removal rates found in the 1978 survey

BOD_5 removal in pond 1	45-50%
BOD_5 removal for whole system	90%

Sludge buildup is difficult to estimate although there were some exposed sludge banks near the inlets and in the dead areas of ponds away from the aerators. These areas were also covered by a scum, although this scum was largely made up of material which should be removed by the screen when it becomes operation.

e) The implementing agency appears happy with the pond system.

f) Effluent reuse is being practiced for more than half the year as described above.

g) No chlorination is carried out.

2.5 Problems.

The major problems relate to poor maintenance and the lack of preliminary treatment.

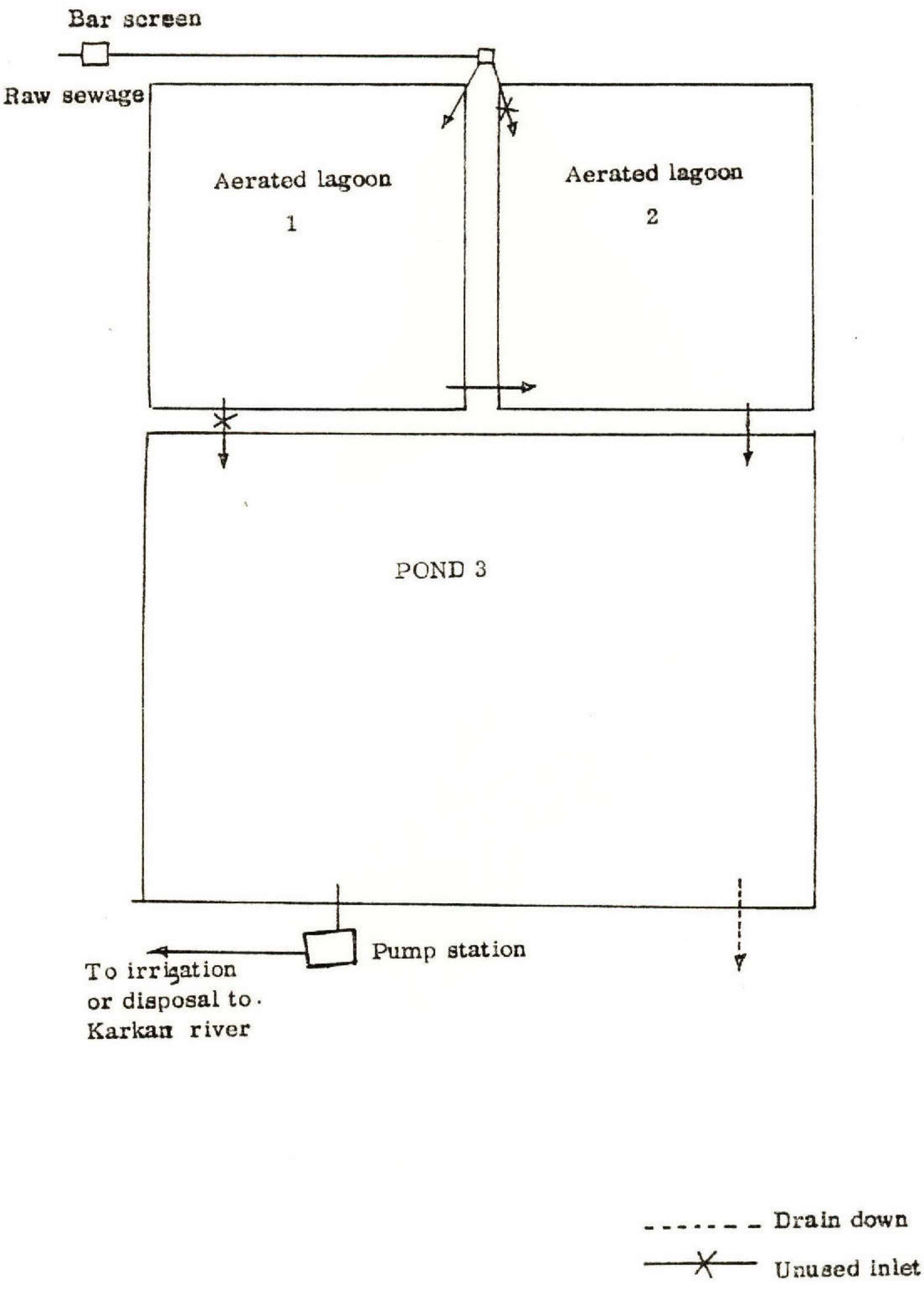
2.6 Recommendations.

i) The automatic bar screen should be brought into operation as soon as possible.

ii) The municipal employees responsible for maintaining the town's sewerage system and operating the treatment plant (6 in number) should make efforts to repair the eroded embankments, clear the vegetation and keep the ponds clear of scum.

RAMAT HASHARON - SCHEMATIC DIAGRAM.

Not to scale.



C2.3 BET SHEMESH, ISRAEL,

May 21st

Client: Local Council - Bank Funded.

3.1 Design.

a) No client resistance to use of ponds.

b) Design based on empirical loadings for anaerobic ponds. Aerators included in project since the kibbutz on whose land the system was constructed, insisted on the inclusion of aerators as a insurance policy.

Design Parameters.

Population	25,000 for 1985.
Per capita wastewater contribution	150 l/c/d
Daily average wastewater flow	4,700 m^3/day
Per capita BOD_5 contribution	65 g/capita
BOD_5 mg/l	425 mg/l
BOD_5 kg/day	2,000

This flow rate includes 90 m^3/day from the kibbutz (TZORA) population 700, and about 25% for industry.

The wastewater is pumped to the ponds by 2 no. 250m^3/h low lift pumps.

System comprises 2 no. aerated lagoons, with provision for an additional unit in the future, and 2no. polishing ponds (again with 2 no. future units proposed) and a storage pond.

Pond Characteristics (Design).

	Aerated lagoons 1 and 2	Polishing Ponds 4 & 5	Storage Pond 8.
Volume m^3	2 x 13100		
Depth m	4	1.5	4
Freeboard m	1	0.7	0.7
Liquid surface area ha	2 x 0.49	2 x 1.27	1.25
Side slope	1 : 3	1 : 3	1 : 3
Detention time days	5.5	4.0	8.5
Aerators HP	4 x 30HP	-	-
Power supply	3.2 watts/m^3	-	-

Design loading rates for the primary units were,

	Lagoons 1 and 2	Lagoons 4 and 5.
Volumetric	0.076 kg/m^3/day	
Areal	2040 kg/ha/day	340 kg/ha/day*

* Assuming 60% removal in ponds 1 and 2.

c) The soil is a silt alluvium interspaced with stones and gravel. Some clay was brought onto the site and was used along with selected excavated material for the embankment construction. Clay was used on the embankments and on the pond floor where percol ation problems were expected. The kibbutz estimates that about 1/3 of the total inflow is lost in evaporation (4.5mm/day) and percolation (3-4 mm/day).

Rock chips have been used as embankment protection on the aerated lagoons but no protection is provided for the polishing ponds.

Interpond connections are via surface draw offs (no scum guards) and submerged inlet pipes.

Preliminary treatment is provided by a comminutor at the inlet to the pumping station.

A complex series of interconnecting pipes and manholes allows the ponds to be used in a variety of arrangements, and ponds to be bypassed or drawn down.

d) A 2m high fence is provided comprising 1.8m of chain link fencing topped by 3 strands of barbed wire. The fence is mounted on angle iron posts at 4m intervals.

e) No landscaping or special planting for erosion control has been carried out. Access to the pond system and around the ponds is good with granular wearing course provided on embankments.

f) No lighting is provided.

g) There is no laboratory.

h)

Gross are of site	10ha
Net area of ponds	4.75ha
Existing reserved land	4ha

The land is kibbutz owned and the ponds are 1km from the nearest housing and 1km from the nearest main road.

i) There is no algal harvesting or fish farming.

j) All the effluent is stored in the reservoir and reused for spray irrigation of cotton (200ha) and drip irrigation of vineyards and almond groves (200ha). Two reservoirs are used one of 450,000m^3 and one of 250,000m^3.

k) The itemised estimated costs at time of bidding were not available.

3.2 Bidding.

The list of bids received was not available. All contractors were prequalified or registered in Israel, and the lowest bid secured the contract.

3.3 Construction.

The normal range of mechanical earth moving and compacting equipment was used in construction.

The breakdown of actual capital costs for the construction of the ponds is given below. The treatment plant was constructed between 1975 and 1979, but the costs are adjusted to US$ at October 1980 rates:-

Civil Works	US$	580,000	60%
Mechanical Equipment & Power Connections	US$	200,000	20.5%
Land costs	US$	70,000	7.2%
Engineering	US$	120,000	12.3%
	US$	970,000	

Assuming a design population for 1985 of 25,000 and disregarding investment in infrastructure for future target population, the cost per capita is $ 39.

Cost overrruns were incurred due to earthwork problems. The increase over the contract price was about 4% and within the 10% contingencies allowance.

3.4 Operation.

a) No special start up procedures were used and no special problems were encountered in the early stages. The aerators are still not being used since they are not considered necessary. Without them the aerated lagoons operate satisfactorily as facultative ponds.

b) A member of kibbutz Tzard is responsible for the operation of the pond system and management of the water for irrigation. There is no special training, and operation and maintenance manuals do not exist.

c) Information on operational costs is not available. In this case it comprises only cost of chemicals for spraying and power for pumping from the ponds to the irrigation reservoirs.

d) There is no system for monitoring pond performance or effluent quality. There are no statutory effluent quality standards to be achieved.

Sludge build up and weed growth are not a problem at present. The embankments are sprayed regularly to keep vegetation down.

Evaporation is 4.5mm per day on average.

Kibbutz estimates 1/3 of inflow lost through evaporation and seepage .

The actual daily average flow is estimated at 2,250m^3/day and BOD_5 load at 800 kg/day. These figures give the following pond characteristics (actual).

	Ponds 1 and 2	Ponds 4 and 5	Pond 8
Detention time(days)	11.5	8	17.5
Organic loading rate, areal	820 kg BOD_5/ha/day		
volumetric	31 grams/m^3/day		

(aerated lagoons 1 and 2 are now operating as facultative ponds).

The pond system is very flexible as it stands with aerators and reserved land which could be used should the need arise.

e) Both the kibbutz and the town council appear to be satisfied with the operation of the pond system.

f) The kibbutz are very happy with the sewage effluent as a means of increasing their crop yields. They would undoubtedly be able to make use of more effluent were it available.

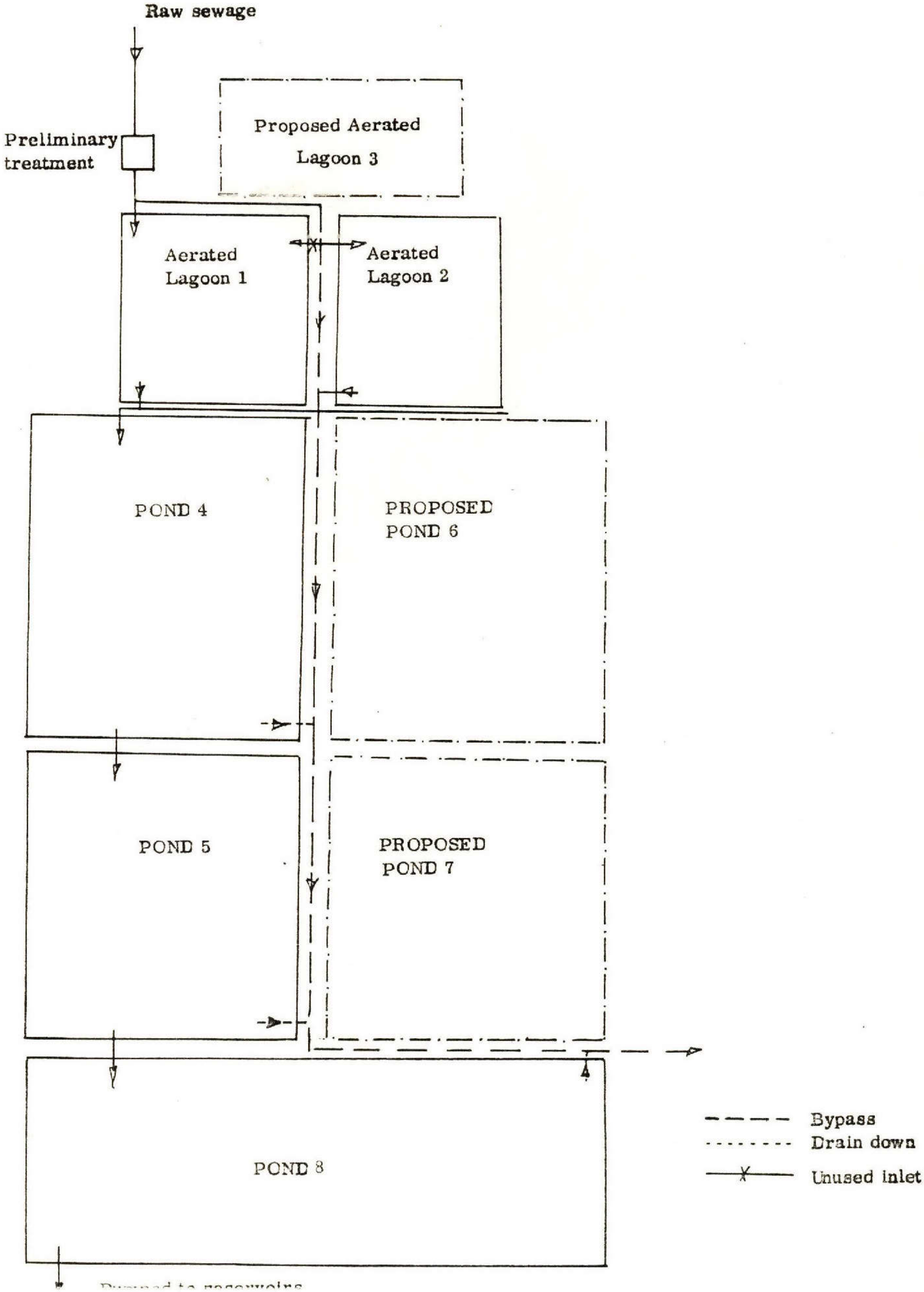
g) There is no chlorination of the pond effluent. Dosing with chlorine is not considered necessary with the long detention times used in the pond system and reservoir.

3.5 <u>Problems and Recommendations</u>.

The major problems relate to general maintenance of the system which should be improved.

BET SHEMESH - SCHEMATIC DIAGRAM

Not to scale.



C2.4 RAMLE, ISRAEL

May 21st

Municipal status: Town.
No project.

4.1 Design.

a) No evidence of resistance to ponds, land leased by Municipality from Kibbutz.

b) Design appears to be based on empirical loading rates for anaerobic/facultative ponds.

Design parameters and actual values for these parameters in 1981 as follows:-

TABLE C2.4.1

		design value (1985)	1981 value
Population		50,000	41,500
Per capita wastewater contribution	l/c/d	150	140
Daily average wastewater flow	m^3/d	8,500	5,810
Per capita BOD_5 contribution	g/c/d	50	50
BOD_5	mg/l	294	357
BOD_5	kg/day	2,500	2,075

Raw sewage is delivered to the pond system via a low lift pump. Three settling tanks are provided in series with the pond system but are not operational. The pond system itself comprises two anaerobic/facultative ponds in parallel.

Pond Characteristics.

		Pond 1	Pond 2
Volume	m^3	16,050	32,100
Depth	m	1.5	1.5
Freeboard	m	0.75	0.75
Liquid surface area	ha	1.07	2.13
Side slope inside		3:1	3:1
Side slope outside		3:1	3:1
Actual detention time	days	8.3	8.3
Actual BOD_5 loading rate			
- volumetric	$kg/m^3/day$	0.043	0.043
- areal	kg/ha/day	600	600

Assuming that 30% BOD_5 reduction would have been achieved in the primary sedimentation tanks had they been operational, the design loading rates were,

Areal BOD_5 loading rate	547	kg/ha/day
Volumetric BOD_5 loading rate	0.036	$kg/m^3/day$

The industrial equivalent ia about 6,500 people or 15.7% of the total population served.

c) The soil is a silty clay and local material was used in embankment construction so no additional material was required from off the site. There are no noticeable percolation problems.

There is no levee protection, but little evidence of serious embankment erosion.

The pond inlets are multiple and above the surface, outlets are simple and at the surface, and include scum boards.

There is no flow measuring device and the preliminary treatment sedimentation tanks are not functioning properly. No bypass is provided except to divert the whole flow from the pump station to the nearby creek.

d) Fencing comprises 2.0m high 5 strand barbed wire fencing, and is generally in very poor repair.

e) There is no landscaping and little vegetation growth on embankment sides. Reasonable access is provided by a dirt roadway down the central embankment of the ponds although this is littered with junk.

f) There is no lighting.

g) There are no laboratory facilities.

h) The net area of pond is 3.2 ha.
The gross area of the site is 4.8 ha.
There is no existing reserved land.
The land is leased from the kibbutz by the municipality and the ponds are 0.9 km from the nearest housing and 0.1 km from the nearest road.

i) There is no ancillary use of the ponds.

j) The effluent is used directly for irrigation by Kibbutz Netzer Sireni during the irrigation season of June to August. During the remainder of the year the effluent is pumped to the storage reservoir owned by Kibbutz Naan (see annex C2.4A).

k) The itemised costs at time of bidding were not available.

4.2 Bidding.

A list of bids received was not available. Procurement was by the normal process using standard procedures for considering bids by registered or prequalified contractors.

4.3 Construction.

No information was available on the equipment used in construction or on the specified compaction requirements.

No information was available on the final costs of construction or the appropriate unit costs.

4.4 Operation.

a) The nature of any start up procedures which were used are unknown.

b) Maintenance is carried out by the municipality who employ one foreman and four workers to look after the complete town sewerage system and the ponds. No special training in pond operation is provided, and there are no organisation or maintenance manuals.

c) No information was available on the operational costs which comprise only labour.

d) There is no pond performance monitoring system. The only information available on the pond system are values for the hydraulic and organic loading rates as follows,

1971	Population	34,000	
	BOD_5 loading	1,500	kg/day
	BOD_5 contribution	45	g/capita/day
1976	Population	37,000	
	Hydraulic loading rate	4,800	m^3/day
	Wastewater contribution	130	l/capita/day

In 1980 the flow rate was evaluated at 5,800 m^3/day.

The ponds appear not to be operating as facultative units since algal concentration was low. Some exposed sludge banks were observed although no particular odour problems were noticed. There was no sign of regular maintenance, and some large items of junk has been dumped into the ponds. There is some flexibility built into the system in that it appears to be possible to run the ponds either in series or in parallel.

e) The implementing agency appears to be satisfied with the pond system.

f) The effluent reused by Kibbutz Netzer Sireni is used to irrigate cotton and maize.

g) There is no chlorination of the effluent.

4.5 Problems.

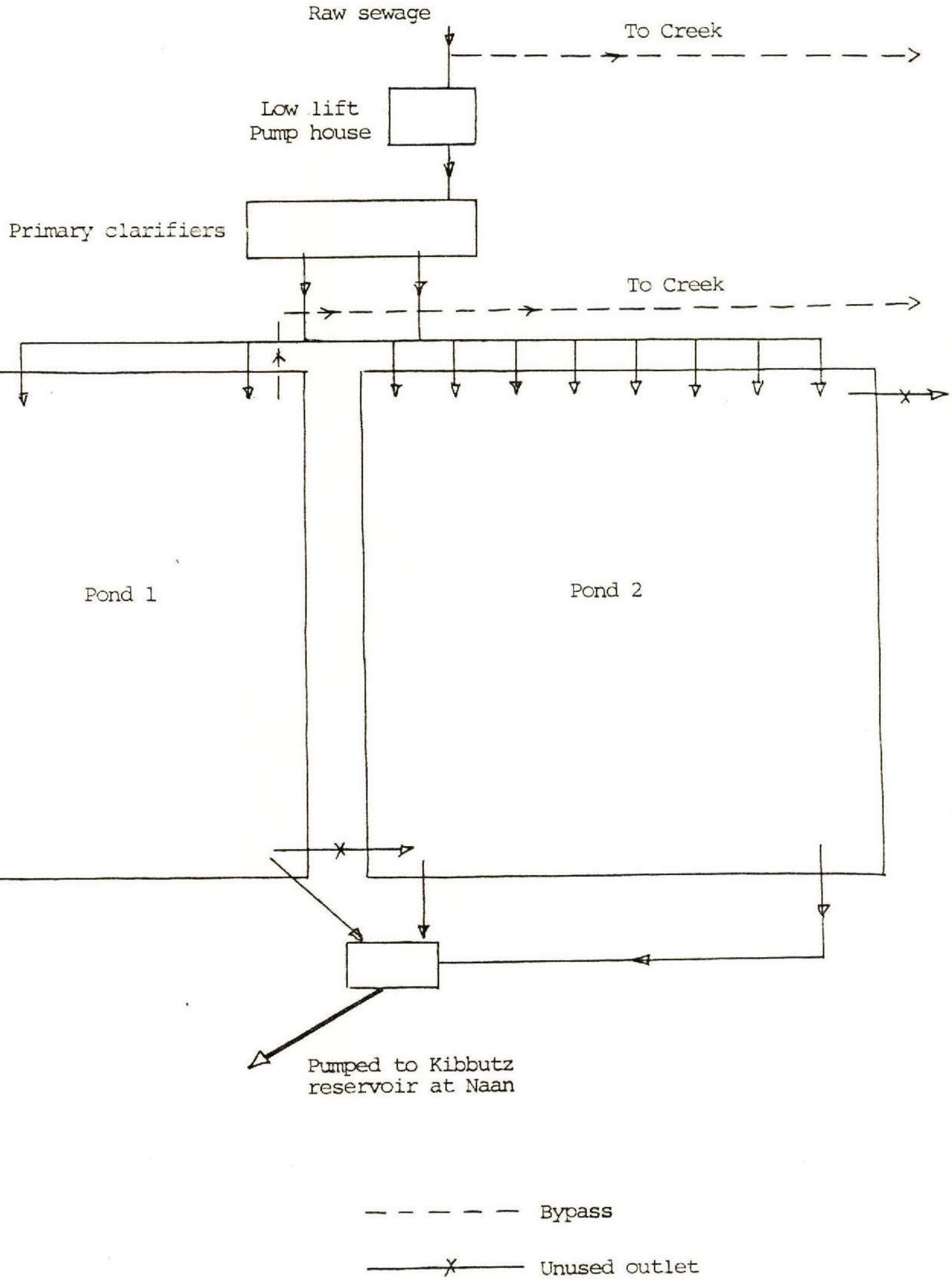
The major problems relate to the lack of maintenance and security.

4.6 Recommendations.

i) The ponds would operate better with a reduced loading rate. This could be achieved by rehabilitating the settlement tanks which would then remove a high proportion of influent $B.O.D._5$.

ii) Maintenance improvements should include removal of exposed sludge banks and objects from the ponds. Unfenced sections of the boundary should be refenced to deter the public from entering the site.

RAMLE - SCHEMATIC DIAGRAM



C2.4A NAAN, ISRAEL

May 21st

Kibbutz Irrigation Reservoir and Ponds.

4A.1 Design.

a) The ponds and reservoir were constructed by the Kibbutz on Kibbutz land and are geared towards maximum utilisation of sewage for irrigation. The two anaerobic/facultative ponds were provided at the insistance of the Ministry of Health.

b) A system of two anaerobic/facultative ponds in parallel, are run in series with the irrigation reservoir. Inflow to the ponds comprises approximately 600 m^3/day. Settled sewage from the Kibbutz plus approximately 4,000 m^3/day of effluent pumped from the Ramle treatment plant (see C2.4). This flow rate is only achieved from September to April. For the remainder of the year the effluent from Ramle is used by Kibbutz Netzer Sireni for irrigation and only 600 m^3/day settled sewage from Kibbutz Naan flows to the ponds.

The design of the ponds appears to have been based on provision of sufficient detention time to achieve some reduction in BOD_5. The reservoir is designed according to the irrigation needs. The reservoir has sufficient volume to provide the required quantity of irrigation water during the cotton irrigation season. The pond characteristics are shown below:-

Characteristics		Pond 1	Pond 2	Reservoir
Volume	m^3	5,000	5,000	750,000
Depth	m	1.6	1.6	8.0
Freeboard	m	0.5	0.5	0.5+
Liquid surface area	ha.	0.54	0/54	10.0
Side slope - inside		1:3	1:3	1:3.5
- outside		1:2.5	1:2.5	1:2.5
Detention time	days	2.0*	2.0*	163
BOD_5 loading	kg/ha/day	725*	725*	N/A

* Detention times and loading rates relate to period when influent includes Ramle works effluent.

c) The soil at the site is an upper layer of red clay overlaying strata of silt and sand. Thus a plastic sheet was used to line the floor of the reservoir. Polyethylene sheeting was used of thickness 0.25mm and overlapped and glued. The sheeting extends only to the bottom of the embankment slope in some areas, and in others to halfway up the embankment. The embankments are constructed with a core of clay excavated from the site. No off site material was required in construction.

The ponds are without any form of embankment protection although the reservoir is provided with some loose rock embankment protection at water level.

There are dual above surface inlets to the ponds, and the outlets are at the surface with scum guards provided. The connections between the ponds and reservoir are provided by simple pipes discharging at or above the surface of the reservoir. All inlets and outlets are kept high to avoid puncturing the plastic layer.

There are no particular percolation problems. Total losses have been evaluated at 7mm/day, of which about 4.5mm may be accounted for by evaporation.

There is pretreatment at the Ramle treatment plant for most of the inflow, and the remainder is pretreated in a settlement tank at the Kibbutz.

d) The site is fenced with a 2m high chainlink fence topped with 3 strands of barbed wire. Fence posts are approximately 3.5m apart.

e) There is no planting on the external embankments and this has resulted in erosion problems. Access around the ponds and reservoir is good since the embankments are topped with a surface dressing of gravel.

f) There is no lighting provided.

g) No laboratory is provided.

h) Gross area of site 15 ha
Net area of ponds and reservoir 11.1 ha
Existing reserved land - None
Distance from the nearest area of housing is 2 km.
Distance from the nearest main road is 1 km.
The site is owned by the Kibbutz, and is surrounded by cultivated land.

i) There is no fish farming, nor have any other methods of algal harvesting been considered.

j) The water is pumped from the reservoir to irrigate 200 ha. of cotton during the months of May to September.

k) The itemised estimated costs at time of bidding were not available.

4A.2 Bidding.

The list of bids received was not available. Government help was provided in the funding of the construction.

4A.3 Construction.

No information was available on the construction method used. However, it appears that the usual range of mechanical earth moving and compacting equipment was used in construction. No data was available on unit costs or total final costs of construction of the ponds.

4A.4 Operation.

a) No special start up procedures appear to have been used, and no odour problems were recorded in the early stages of operation.

b) Kibbutz Naan operates the pond system and manages the effluent for irrigation. There is no special training, and operation and maintenance manuals do not exist.

c) Operational costs were not available, but apart from the cost of pumping into and out of the ponds, operation and maintenance costs are likely to be very low.

d) Occasional monitoring of the influent to and effluent from the ponds has been undertaken, although there is no regular monitoring of the system. The most recent results are as follows:-

	Oxidation Ponds		Reservoir
Parameter	influent	effluent	effluent
BOD_5	170 mg/1		40 mg/1
Total Bacteria	1.8×10^6	5.3×10^5	2.2×10^5
Total Coliforms	2.3×10^6	20	20

There are no mandatory effluent standards which have to be satisfied.

No odours or scum was noticed although some odours are reported in winter. No problems are encountered with sludge buildup or weed growth.

Total losses are 7mm per day.

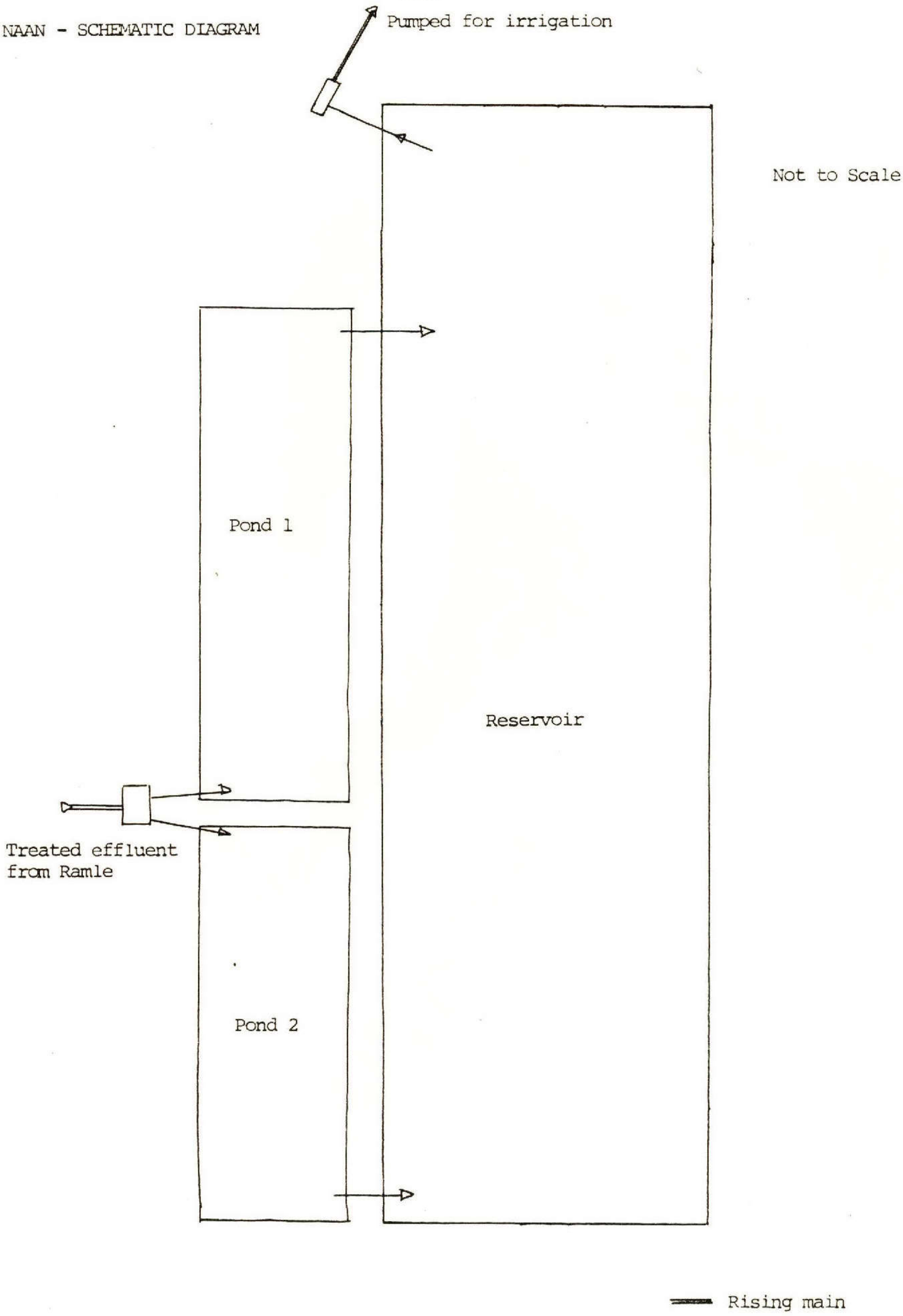
There are no special facilities for coping with effluent change, climatic change, overload or enhanced flow. The pond system contains little flexibility since the oxidation ponds cannot be run in series. The large volume of the reservoir provides some degree of flexibility.

e) The Kibbutz appears to be quite happy with the pond system and reservoir.

f) The effluent is reused for the spray irrigation of 200 ha. of cotton during the months from May to August.

g) There is no chlorination of the effluent.

NAAN - SCHEMATIC DIAGRAM



C2.5 LOD, ISRAEL

May 21st

Client: Town Council
Improvement Works Bank Funded

5.1 Design.

a) No particular client resistance to original use or extension of pond system.

b) Design of the present aerated lagoon system was based on empirical loading rates and detention times.

Design Parameters.

Population (design forecast)	42,000 (1979)
Additional equivalent from industry	1,000 m^3/day
Per capita wastewater contribution	125 l
Daily average flow	6,200 m^3/day
BOD_5	370 mg/l
BOD_5 load	2,300 kg/day

The previously existing pond system was enlarged and aerators were added. Financial responsibility for the electromechanical equipment only was accepted by the World Bank because the improvements were defined as temporary works. The earthwork component was funded by the municipality. The system now comprises two aerated lagoons in series.

The pond characteristics of the rehabilitated system are,

		Pond 1	Pond 2
Volume	m3	23,000	30,000
Depth	m	3.5	1.8
Freeboard	m	0.5	0.5
Liquid surface area	ha	0.8	2.0
Side slope (inside)		1:3	1:3
Side slope (outside)		1:3	1:3
Aerators		2 x 40 H.P.	4 x 15 H.P.
Power rating	watts/m^3	2.6	2.0
Detention time (design)	days	3.7	4.8
Organic loading rate (design)	kg/m^3/day	0.1	-

c) The soil is a clay, and no extra embankment material was brought onto the site during reconstruction. There is no pond lining, and embankment protection at the water level is provided by rock chippings.

Interpond connections are via surface draw offs and subsurface inlets, there is a baffle in pond 2 which divides the aerated portion from the quiescent portion.

There is no bypass, and preliminary treatment is provided by a manually cleaned bar screen. Evaporation losses are about 4mm per day.

d) A 2 meter chain link fence is provided, topped with 3 strands of barbed wire.

e) The external embankments are vegetation covered and do not appear to suffer serious erosion problems. The ponds are provided with good gravel access roads around their perimeter.

f) No lighting was provided.

g) There are no laboratory facilities.

h) The net area of the ponds is 2.8 ha
The gross area of the site is 4.5 ha
There is no reserved land.
The land is within the municipal boundary and is thus owned by the town council. The site is about 1 km from the nearest main road and 100 m from the nearest housing.

i) There are no ancillary uses of the ponds.

j) During the summer the effluent is pumped for spray irrigation of the citrus orchards. For the remainder of the year the effluent overflows to a small creek.

k) Costs at time of bidding were not available.

5.1 Bidding.

A list of the bids received was not available. Standard procedures were used in procurement.

5.3 Construction.

Normal mechanical construction methods were employed. The earthworks which included the cleaning and deepening of the previously existing ponds was paid for by the municipality from their funds. This could not be paid for by the I.B.R.D. loan because it was defined as temporary works. The aeration equipment did come under the bank loan. The 1974 value of this equipment including electrical installation was $55,000. No information was available on the cost of the full rehabilitation, or whether cost overruns were incurred.

5.4 Operation.

a) No special start up procedures were used. No odours have been experienced since the addition of the aerators. There were odour problems prior to the rehabilitation works.

b) The system is operated by the national water company Mekorot. There are no permanent staff, but trained staff visit the pond system regularly. There are no maintenance manuals used by the operators.

c) No data was available on the maintenance costs, although they tend to be on the high side when Mekorot are used.

d) There is no pond monitoring system and no records of readings of pond treatment parameters were available.

e) The town appears to be satisfied with the system since the rehabilitation works.

f) Effluent reuse for irrigation during half the year is described in detail above.

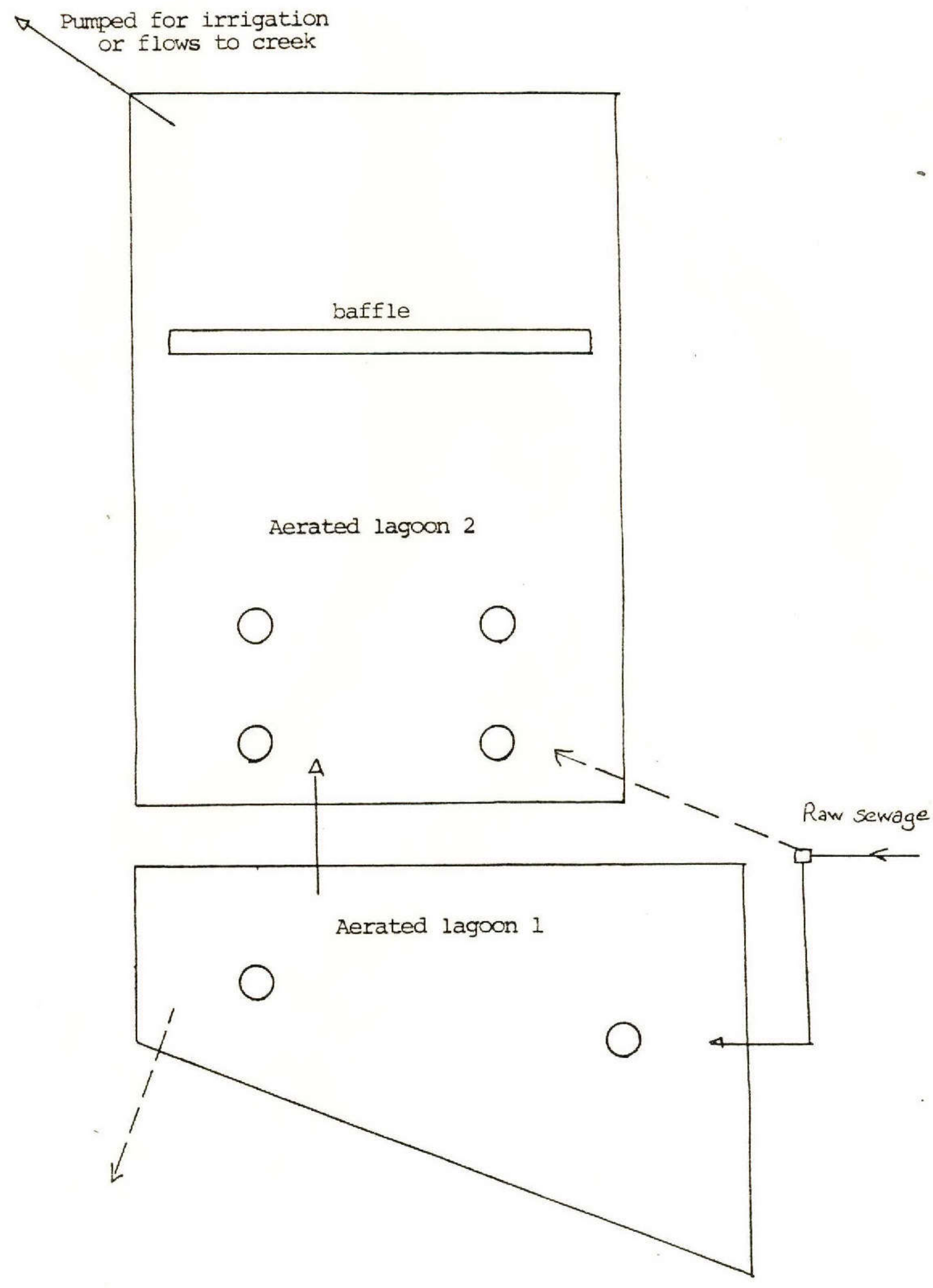
g) There is no effluent chlorination.

5.5 Problems and Recommendations.

a) The bar screen is not cleaned regularly and becomes clogged with material. Regular monitoring and cleaning should be carried out.

LOD - SCHEMATIC DIAGRAM

Not to scale



— — — — Overflow bypass

C2.6 OR YEHUDA, ISRAEL

May 21st

Client: Local Council
No bank funded project.

6.1 Design.

a) No client resistance to use of ponds.

b) Design was based on standard loading rates for anaerobic ponds.

Design Parameter		Improvement design assumptions	actual
Year		1985	1981
Sewered Population		67,000	47,000
Per capita wastewater flow	l/c/d	160	140
Daily average flow	m^3/day	10,700	6,500
BOD_5 contribution	g/c/d	55	50
BOD_5	mg/l	345	353
BOD_5	kg/d	3,680	2,300

The flow rate includes about 6% from industry.

The raw sewage flows by gravity into the wet well of a low lift pumping station. The pond characteristics of the existing system are,

Ponds Characteristics		Ponds 1&2	Ponds 3&4	Ponds 5&6
Volume	m^3	2x1,800	2x5,600	2x8,400
Depth	m	2	1.5	1.5
Freeboard	m	0.5	0.5	0.5
Liquid surface area	ha.	2x0.1	2x0.4	2x0.6
Side slope inside		3:1	3:1	3:1
Side slope outside		3:1	3:1	3:1
Detention time (design)	days	0.9	2.7	2.1 each
Loading rate (design)				
areal	kgBOD_5/ha/day	5,200	-	-
volumetric	Kg/m^3/day	0.29	-	-

c) The soil is a clayey silt and no additional material was used for embankment construction or pond lining. None of the ponds include embankment protection, but the system is provided with a central bypass. Interpond connections were via surface draw offs and below surface inlets.

Raw sewage is pumped to pretreatment Imhoff tanks via low lift pumps.

Evaporation in the area is 4mm/day.

d) There is no fencing of the plant.

e) There is no landscaping around the ponds which are completely overgrown both inside and outside the ponds. Access is very poor around the pond system.

f) There is no lighting.

g) There is no laboratory equipment.

h) Gross area of site 3.5 ha.
Net area of ponds 2.2 ha.
There is no existing reserved land.
Distance from the nearest housing is 0.5 km and from the nearest main road is also 0.5 km.

i) There were no ancillary uses of the ponds when they were operational.

j) There was no effluent reuse when the ponds were fully operational.

k) The itemised costs of construction at the time of bidding were not available.

6.2 Bidding.

Information on the bids received for the original construction of the ponds was not available. Procurement information was also not available.

6.3 Construction.

No information was available on the construction, which would have been by mechanical methods, or the final costs of construction.

6.4 Operation.

a) No special start-up procedures were used, and no nuisance was experienced in early stages of operation.

b) The pond system is operated by the Municipality of Or Yehuda who own the plant. Most of the flow comes from other municipalities, particularly Kiryat Ono. Two operatives are provided by the municipality of Or Yehuda to operate the system. The operatives are untrained and there are no organisation or maintenance manuals.

c) No information was available on the operational costs although all the municipalities contributing sewage to the Or Yehuda plant contribute money for the system's maintenance. The money actually spent on operation is only the wages of the operatives and power for the pumping. Expenditure appears to be very low and may not reflect the value of the contributions from the other municipalities.

d) The pond system is completely inoperative at present. The raw sewage is pumped to the Imhoff tank from where it overflows and runs straight through the pond system to the creek in a single stream. The operatives were of the opinion that since the effluent was not being reused for irrigation, treatment of the raw sewage in the pond system was not necessary.

The original pond system had no performance monitoring system and no facilities for coping with enhanced inflow, effluent change, etc. The design offered some flexibility in the parallel operation of ponds 1 and 2, and 3 and 4.

e) Implementing agency is either unaware of the breakdown of the system or is not concerned with it.

f) Effluent reuse for irrigation of citrus groves was planned, but was never carried out.

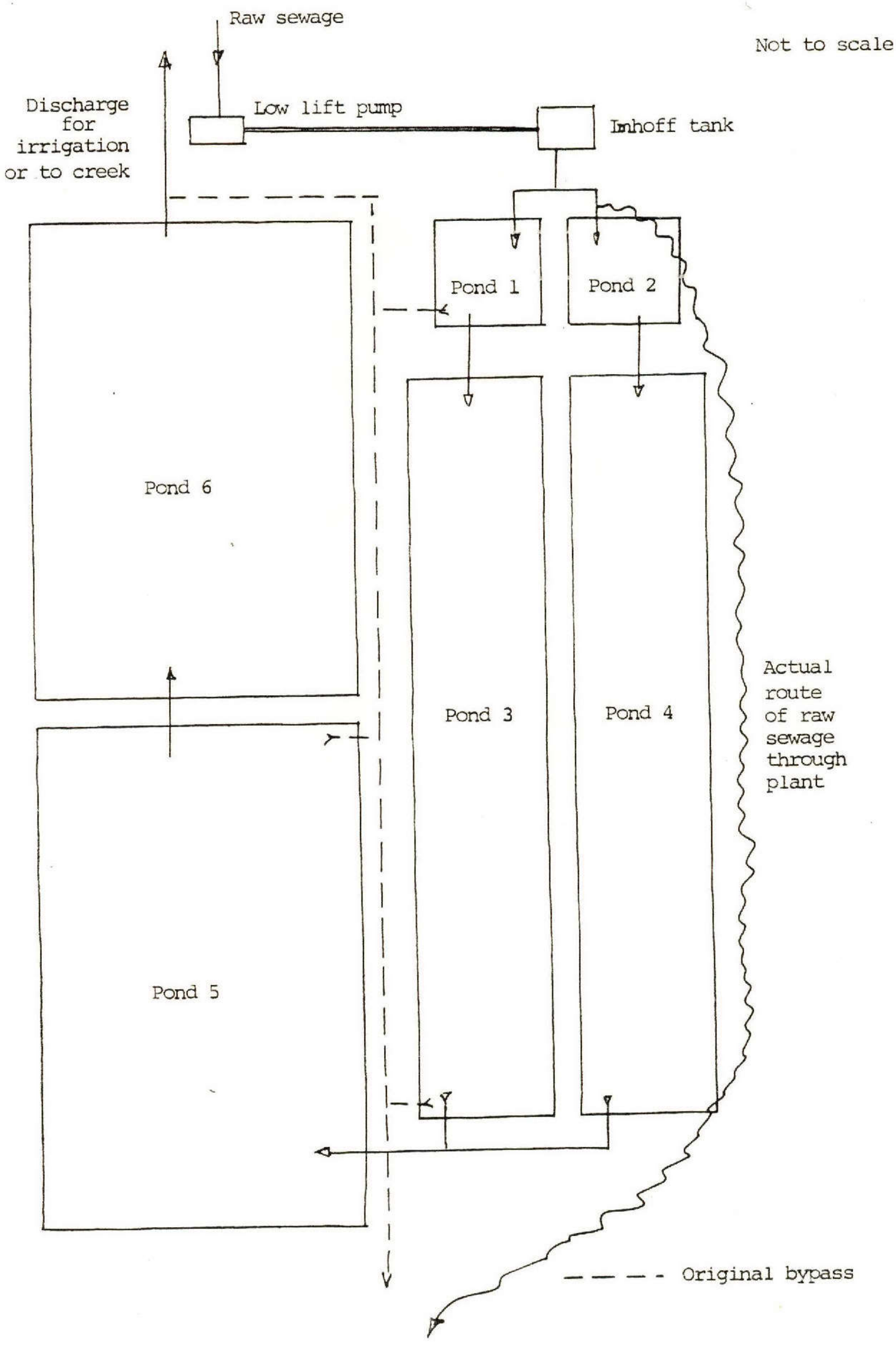
g) No effluent chlorination was planned.

6.5 Problems and Recommendations.

a) The system is not operational and the degree of treatment achieved is minimal.

b) Complete reconstruction of the system is required. Some retention of the raw sewage could be provided in temporary ponds whilst the new permanent system is designed and constructed.

OR YEHUDA - SCHEMATIC DIAGRAM



C2.7 NETANYA, ISRAEL

May 22nd 1981

Client: Town Council
Bank funded.

7.1 Design.

a) No client resistance to use of ponds.

b) Design based on standard loading rates and power supplied per m^3 of pond liquid.

Design Parameters

Parameter		Design forecast 1985	Actual
Population		100,000	100,000
Wastewater contribution	l/c/d	160	170
Wastewater flow	m^3/d	16,000	17,000
BOD_5 contribution	g/c/d	60	57
BOD_5	mg/l	380	336
BOD_5 load	kg/d	6,080	5,712

The contribution from industry is negligible.

The raw sewage is pumped to the new system (Bet Huret) via the old system (Bet Yizhaq) which is still used to treat a small amount of raw sewage.

The system comprises 3 No. aerated lagoons, a settling pond, 4 No. facultative ponds (2 unused) and 3 No. maturation ponds, plus a sludge drying pond.

The pond characteristics are shown on the next page.

c) The soil at the site is clay which was used in embankment construction. No additional soil from off the site was required. The embankments of the aerated lagoons were protected by a layer of rock chippings at the liquid surface level. No embankment protection was provided for the facultative or maturation ponds.

The inlets are submerged, and in the case of the aerated lagoons emerge under the aerators. Surface outlets from the ponds are provided with scum guards.

Preliminary treatment is provided by screens at the individual pumping stations.

Bypasses to some pond units are provided by an arrangement of pipes and manholes running down the central embankment of the pond system.

d) A 2m high fence is provided with 1.8m high chain link fencing topped with 3 strands of barbed wire. Fosts of angle iron are positioned at 3.5m intervals.

The pond characteristics are,

Pond Characterstic		Aerated lagoon No. 1	Aerated lagoon Nos. 2 & 3	Silting POnds Nos. 5 & 6	Pond NOs. 6 & 7	Pond Nos. 8 & 9	Pond No. 10	Sludge Drying Ponds
Volume	m^3	45,000	2 x 33,000	2 x 6,800	2x23,000	2x18,000	13,200	-
Depth	m	4	4	4	1.3	1.2	1.2	
Freeboard	m	0.8	0.8	0.8	0 8	0.8	0.8	
Liquid Surface Area	ha	1.4	2 x 1.1	2 x 0.2	2 x 1.9	2 x 1.5	1.1	2 x 1.7
Side slope (inside)		2.5:1	2.5:1	2.5:1	3:1	3:1	3:1	-
Detention time - design	days	2.8	4.1	0.5	3.1	2.3	0.9	-
- actual	days	2.6	3.9	0.4	2.9	2.1	0.8	-
Organic Loading - design	$KgBOD_5/m^3/d$	0.135	-	-	-	-	-	-
- actual	$KgBOD_5/m^3/d$	0.127	-	-	-	-	-	-
Aerators	H.P.	4 No. 50	2 x 4 No. 15					
Power supplied	W/m^3	3.3	1.4					
Aerator type		Fixed	Fixed Pond No. 2 Floating Pond No. 3					

e) The outside embankments of the ponds are grassed and access around the ponds is good with gravel access roads.

f) Lighting is only provided at the maintenance building.

g) Laboratory facilities are provided on the upper storey of the maintenance buidling. Equipment and furniture is included sufficient to allow measurement of BOD_5, pH, dissolved oxygen and suspended and total solids.

h) Gross area of site 25 ha.
Net area of ponds 15.3 ha.
Existing reserved land 5 ha.
The land is owned by the municipality and is 0.5 km from the nearest main road and greater than 1 km from the nearest housing area.

i) There are no ancillary uses of the ponds.

j) The effluent is reused for irrigation in the summer and discharged to a receiving channel in the winter.

k) The itemised costs at time of bidding were not available.

7.2 Bidding.

The list of bids received was not available. All bidding contractors were either registered in Israel or were prequalified. Procurement was according to standard Israeli and World Bank practice.

7.3 Construction.

The normal range of mechanical earth moving equipment was used in construction.

The breakdown of actual capital costs for the construction of the pond system is given below. The system was constructed between 1975 and 1979 but the costs have been brought to US$ at October 1980 prices.

Civil Works	$ 1.30 million
Mechanical Works and Power Connection	$ 0.38 million
Engineering Services	$ 0.20 million
Land	$ 0.35 million
Total	$ 2.23 million

With a population of 100,000 this gives a cost per capita for installation of the system of $22.3.

Slight cost overruns on construction were within the normal allowable contingencies.

7.4 Operation.

a) No special start up procedures were used, there was no smell in the early stages of operation.

b) The system is operated by the National Water Company Mekorot. A team of six men is responsible for the treatment plant plus the old treatment plant at Bet Yizhaq and all the city's pumping stations. There are no maintenance or organisation manuals although the team leader is trained in this kind of maintenance work.

c) Operational costs paid by the municipality for the year 1980 were as follows.

Paid to Mekorot for system maintenance	US$ 110,000
Electricity charges	US$ 150,000
Total	US$ 260,000

This corresponds to approximately 4.2 US¢ per m^3 treated or 2.6 US¢ per capita/annum.

d) The pond performance monitoring system is based on weekly readings for the influent and effluent of BOD5, pH, D.O. and S.S. The laboratory is reasonably well equipped and although no further development of the monitoring system is planned there is potential for a more frequent sample analysis or the inclusion of extra parameters. There are no regulatory standards for the effluent. Due to the high algal concentration in the maturation ponds the average BOD_5 of the final effluent is 40 mg/l.

No problems were reported from sludge build up, weed growth or smell problems. The settling ponds are used alternately, each for a few months before emptying. Evaporation losses are 4 mm/day, there are no special facilities for dealing with cold weather, overloading, effluent change or enhanced flow. The old system at Bet Yizhaq is used in the summer as well as the main plant at Bet Huret due to irrigation demand. In the winter only the Bet Huret plant is used, although Bet Yizhaq is kept in good operating order. This arrangement allows some flexibility in the system.

e) The implementing agency is happy with the pond system.

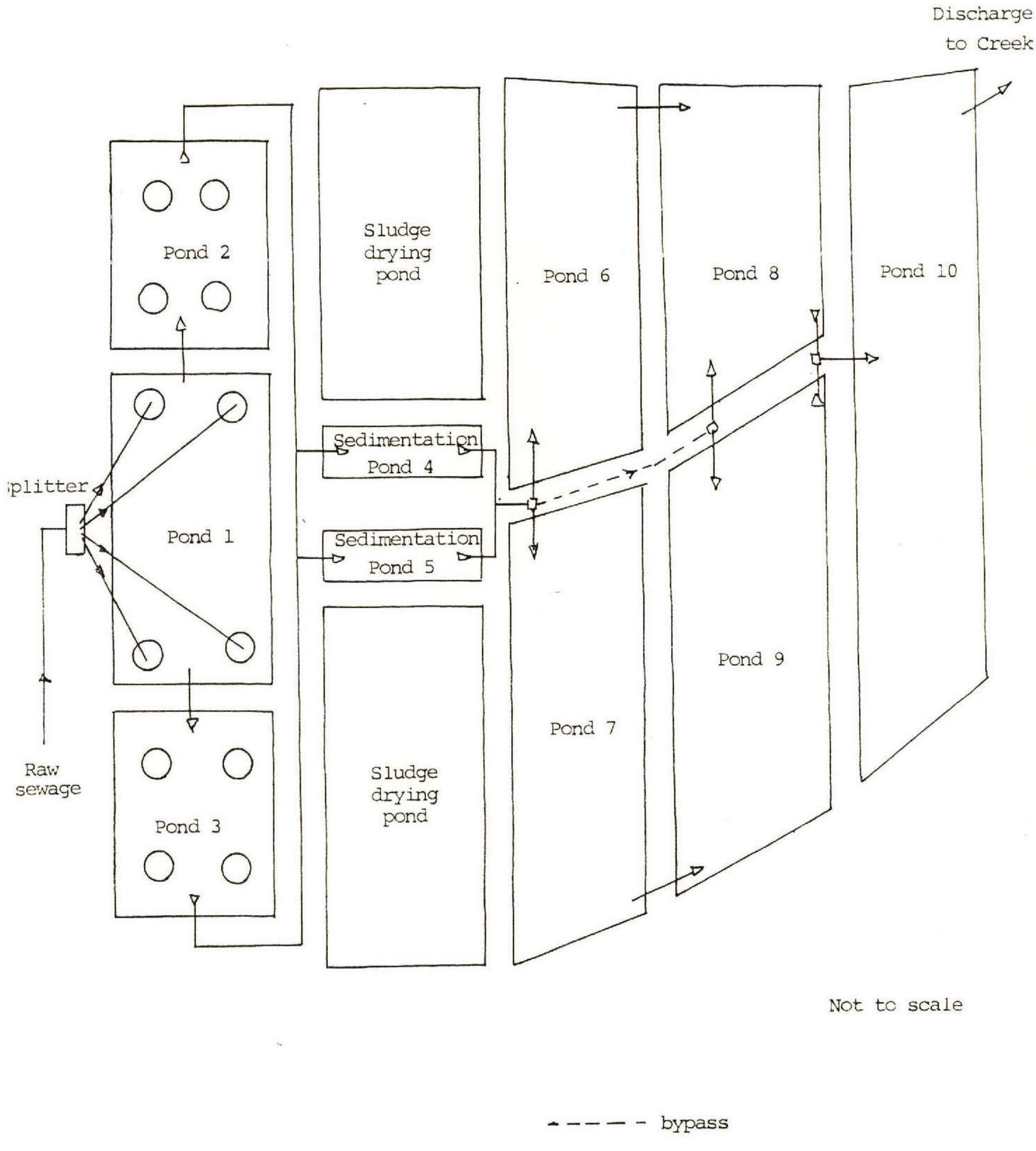
f) The effluent is discharged to a creek in winter but is used from both the Bet Yizhaq and Bet Huret plants in the summer for spray irrigation of clover and alfa alfa.

g) There is no chlorination.

7.5 Problems and Recommendations.

The system appears to be largely problem free. Maintenance of the fixed aerators has been shown to be more troublesome than the floating aerator maintenance.

NETANYA - SCHEMATIC DIAGRAM



C2.8 TEL MOND and EVEN YEHUDA, ISRAEL.

May 22nd 1981

Client: Local Council
Bank Funded.

8.1 Design.

a) System serves two small towns. No resistance to use of ponds.

b) System of anaerobic, facultative and maturation ponds designed on the basis of standard loading rates.

Design Parameters

Parameter		1985 Design assumption	Actual 1981
Population sewered		12,000	3,500
Per capita wastewater flow	l/c/d	100	100
Daily average wastewater flow	m^3/d	1,200	350
BOD_5 contribution	g/c/d	50	25
BOD_5	mg/l	500	250
BOD_5	kg/day	600	100

There is very little contribution from industry.

The inflowing raw sewage is pumped from the towns via a 200 m dia pipe.

The system comprises two anaerobic ponds run in parallel and a series of 3 facultative and maturation ponds.

Pond Characteristics		Ponds 1&2	Pond 3	Pond 4	Pond 5
Volume	m^3	2 x 2,500	3,250	3,900	3,900
Depth	m	3	1.3	1.3	1.3
Freeboard	m	1.25	0.9	0.9	0.9
Liquid Surface Area	ha	2 x 0.12	0.3	0.35	0.35
Side slope		3:1	3:1	3:1	3:1
Detention time - design	days	2 x 3	3.25	3.7	3.7
- actual	days	2 x 10	11	12	12
Organic loading - design	Kg/ha/day	2,500			
	Kg/m^3	120			
- actual	Kg/ha/day	420			
	Kg/m^3	20			

c) The site is on a hillside with local silty clay which was used in embankment construction. There were some percolation problems initially. There is no levee protection, and the ponds are not lined.

Preliminary treatment is provided by screening at the pumping station. There is a Parshall flume at the inlet to the ponds which allows measurement of the raw sewage flow rate.

There are dual above surface inlets to the ponds and surface outlets.

Losses from the ponds are largely due to evaporation of 4mm/day.

There is no bypass of the plant.

d) The fencing comprises 1.8m high plastic covered chain link fence with 3 strands of barbed wire above it. The supports are at 3.5m intervals.

e) There is no landscaping although the outside embankments are vegetation covered. Road access around the ponds is not provided.

f) There is no lighting.

g) There is no laboratory.

h) The land is owned by the kibbutz which uses the effluent for irrigation. They granted the land to the municipalities for construction of the pond system.

Gross area of site	2.2 ha.
Net area of ponds	1.25 ha.

There is no reserved land.

The pond system is 1 km from the nearest housing and 0.3 km from the nearest main road.

i) There are no ancillary uses of the ponds.

j) The effluent is used for spray irrigation of citrus fruit trees and fodder crops.

k) Estimated costs at time of bidding were not available.

8.2 <u>Bidding</u>.

The list of bids received was not available. Bidding and procurement was carried out according to Israeli and World Bank procedures.

8.3 <u>Construction</u>.

The normal range of earth moving and compacting mechanical equipment was used in construction.

The breakdown of actual capital costs for the construction of the ponds is given below. The treatment plant was constructed between 1975 and 1978, but the costs are adjusted to US$ at 1980 rates.

Civil Works	US$ 190,000	68 %
Mechanical and Electrical	US$ 50,000	17.5%
Engineering Services	US$ 40,000	14.5%
Total	US$ 280,000	

Designed for 12,000 thus $23 per capita, disregarding investment in infrastructure.

There do not appear to have been any serious cost overruns during construction.

8.4 Operation.

a) No special start up procedures were used and there are no reports of odour problems in early stages of operation.

b) The system is maintained by the municipality who hire a private contractor who is responsible for the operation and maintenance of the ponds, pumping station and sewerage. The municipality pays 4 to 4.5 thousand U.S. dollars per annum for maintenance of the system, which includes weed spraying. There are no organisation or maintenance manuals.

c) Cost to the municipality for maintenance of the system is between 4 and 4.5 thousand U.S. dollars per annum.

d) There is no system for the regular monitoring of pond performance although a recent analysis of pond treatment efficiency gave the following results.

		Total BOD5	Total C.O.D.
Raw sewage	mg/l	211	400
Primary pond effluent	mg/l	66	196
Secondary pond effluent	mg/l	45	184

There are no regulatory standards, no problems of weed growth, or sludge or scum build up were observed. Although the wind is strong as a result of the hillside site of the ponds, the small size of the units and high freeboard reduce the effect of wind and wave action. There is no special provision for dealing with overloading, cold weather or effluent change. The felxibility of the pond system is increased by the ability to bypass ponds 1,2 or 3.

e) The implementing agency seems quite satisfied with the operation of the pond system.

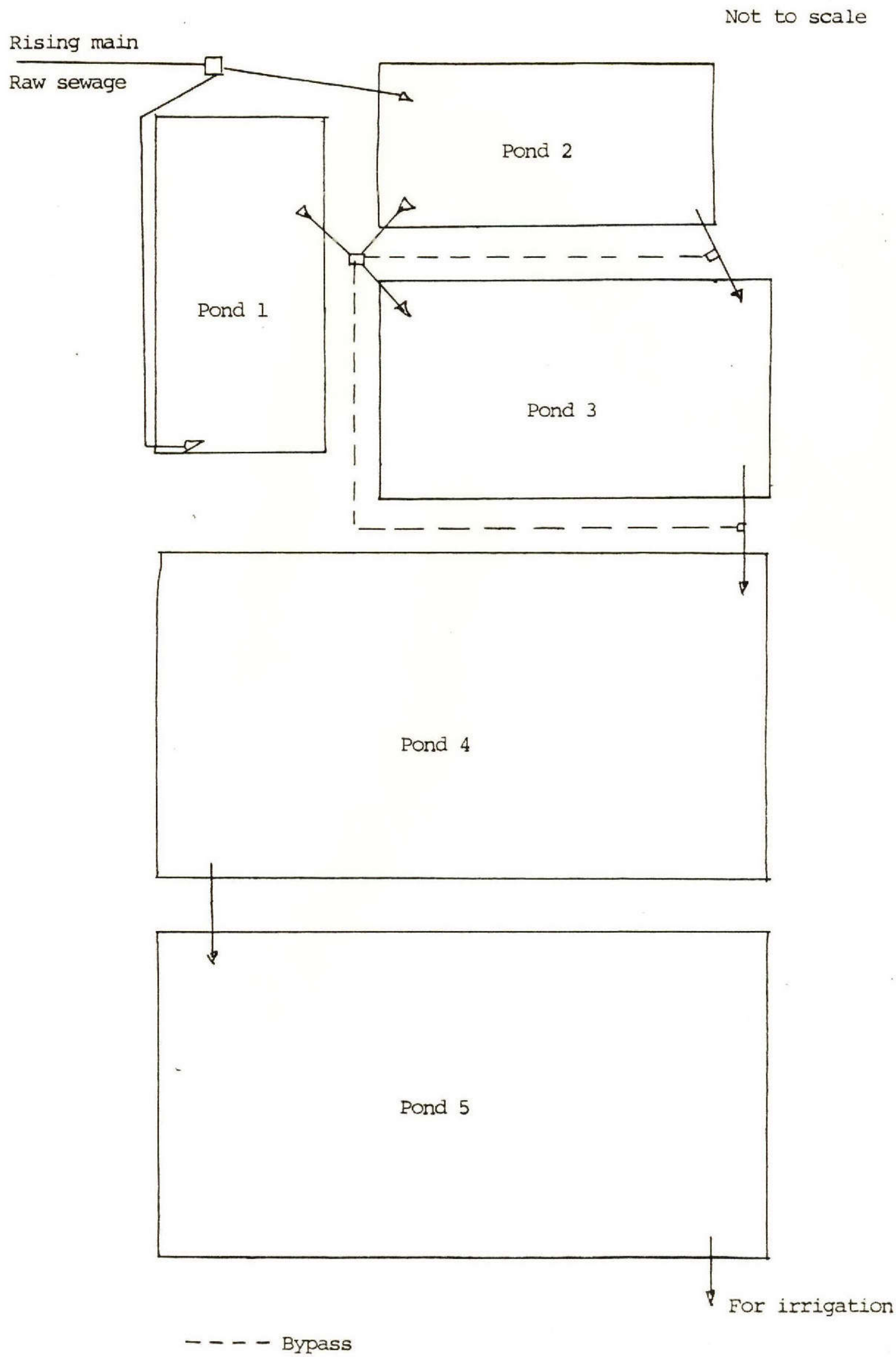
f) Citrus fruit trees and fodder crops are grown successfully using spray irrigation with the pond effluent.

g) There is no chlorination of the effluent.

8.5 Problems and Recommendations.

A small amount of scum was observed on the primary ponds, this should be broken up as part of the routine maintenance duties.

TEL MOND, EVEN YEHUDA - SCHEMATIC DIAGRAM



C2.9 SEDEROT, ISRAEL

May 23rd 1981

Client: Town Council
Bank Funded.

9.1 Design.

a) No particular resistance to use of ponds.

b) Design was based on empirical loading rates for anaerobic ponds.

Design Parameters		Design Assumption	Actual
Population		(1985) 18,000	9,000
Per Capita waste water contribution	l/c/d	140	100
Daily average waste water flow	m^3/d	2,520	2,200*
Per Capita B.O.D.$_5$ contribution	g/c/d	45	35
B.O.D.$_5$	mg/l	321	390*
B.O.D.$_5$	kg/day	810	860

* The wastewater flow comprises 1300 m^3 per day of industrial effluent at a BOD_5 of 420 mg/l, and 900 m^3 of domestic sewage at a BOD_5 of 350 mg/l. This gives a balance of 2200 m^3/day at 390 mg/l BOD_5.

The system is composed of 2 No. anaerobic lagoons run in parallel, 2 No. facultative ponds also run in parallel and a reservoir.

Pond Characteristics		Ponds 1&2	Ponds 3&4	Reservoir
Volume	m^3	2 x 3,600	2 x 15,000	70,000
Depth	m	1.85	1.5	6
Freeboard	m	0.85	0.8	1
Liquid Surface area	ha	2 x 0.2	2 x 1.0	1.6
Side slope inside		1:2	1:2	1:3
Side slope outside		1:2	1:2	1:3
Detention time design	days	2.9	12.0	28.0
actual	days	3.3	13.8	32.0
Organic Load design				
areal	kg/ha/day	2,025	-	-
volumetric	$kg/m^3/day$	0.113	-	-
actual				
areal	kg/ha/day	2,150	-	-
volumetric	$kg/m^3/day$	0.119	-	-

c) The soil is a light sand soil which would not have been suitable as a pond lining. Thus a layer of clayey soil was applied to the pond floors and embankments. This soil was brought from off-site fairly locally and was laid in a 600mm layer.

No protection to embankments was provided at water surface level, and some erosion is occuring as a result.

Interpond connections are via surface outlets and single submerged inlets . There is no preliminary treatment either before or at the plant. A parshall flume is provided for flow measurement before the ponds, but due to the very narrow throat width and lack of preliminary treatment, this frequently becomes blocked.

A bypass enables any of the ponds to be bypassed during cleaning or as necessary.

d) The site is fenced with a 2m high fence of which 1.8m is chain link fencing, topped by three strands of barbed wire. Angle iron supports are at 3.5m centres.

e) No landscaping or special planting for erosion control has been carried out, with the result that embankments are eroded. Access was provided around ponds by means of a dirt road which is now in poor repair.

f) No lighting is provided.

g) There are no laboratory facilities.

h) Gross area of site 4 ha.
Net area of ponds 2.4 ha.
There is no existing reserved land.

The land is Kibbutz owned, and the ponds are 1 km from the nearest main road and 2 km from the nearest housing.

i) There is no algal harvesting or fish farming.

j) All effluent from the ponds is pumped to the reservoir before being used for the spray irrigation of wheat (all year) cotton (summer only) and other crops.

k) The itemised estimated costs at time of bidding were not available.

9.2 Bidding.

The list of bids received was not available. Normal World Bank and Israeli contract procedures were employed.

9.3 Construction.

The normal range of mechanical equipment was employed in construction of the ponds.

The breakdown of actual capital costs for the construction of the ponds is given below. Construction was around 1975 but the costs are adjusted to US$ at October 1980 rates.

Civil Works	US$ 375,000	89%
Engineering Services	US$ 45,000	11%
Total	US$ 420,000	

These costs do not include construction of the reservoir, which gave some problems. Money was paid to the Kibbutz for storage of excavated material on their land.

Assuming a design population of 18,000 the cost of the pond system alone per capita served is US$23.

9.4 Operation.

a) No special start up procedures were employed and no particular problems were encountered early in operation.

b) The system is operated by the Kibbutz. There was no staff training and no operation, maintenance or organisation manuals exist.

c) Operational costs are not known but are very low.

d) Although there is no regular pond monitoring system, some samples were taken for analysis of May 14th and 21st 1981. The results of these tests are given below.

		BOD mg/l	COD mg/l
May 14th	Raw sewage	797	1356
	Pond 1 effluent	346	480
	Pond 3 effluent	124	288
May 21st	Raw sewage	552	
	Pond 3 effluent	62	

There are no regulatory standards. Sludge build up has been high due to large industrial contribution (chicken bones, feathers, etc.). One primary pond being cleaned at time of visit after only 5 years of operation. Double loading on remaining anaerobic pond causing no noticeable odour porblems. Secondary pond also appears largely anaerobic due to double loading.

Embankment erosion appears to be caused more by rain entering ponds than by wave action.

There are no special facilities for coping with enhanced flow, effluent charge, or overload.

e) The municipality appears to be happy with the pond system.

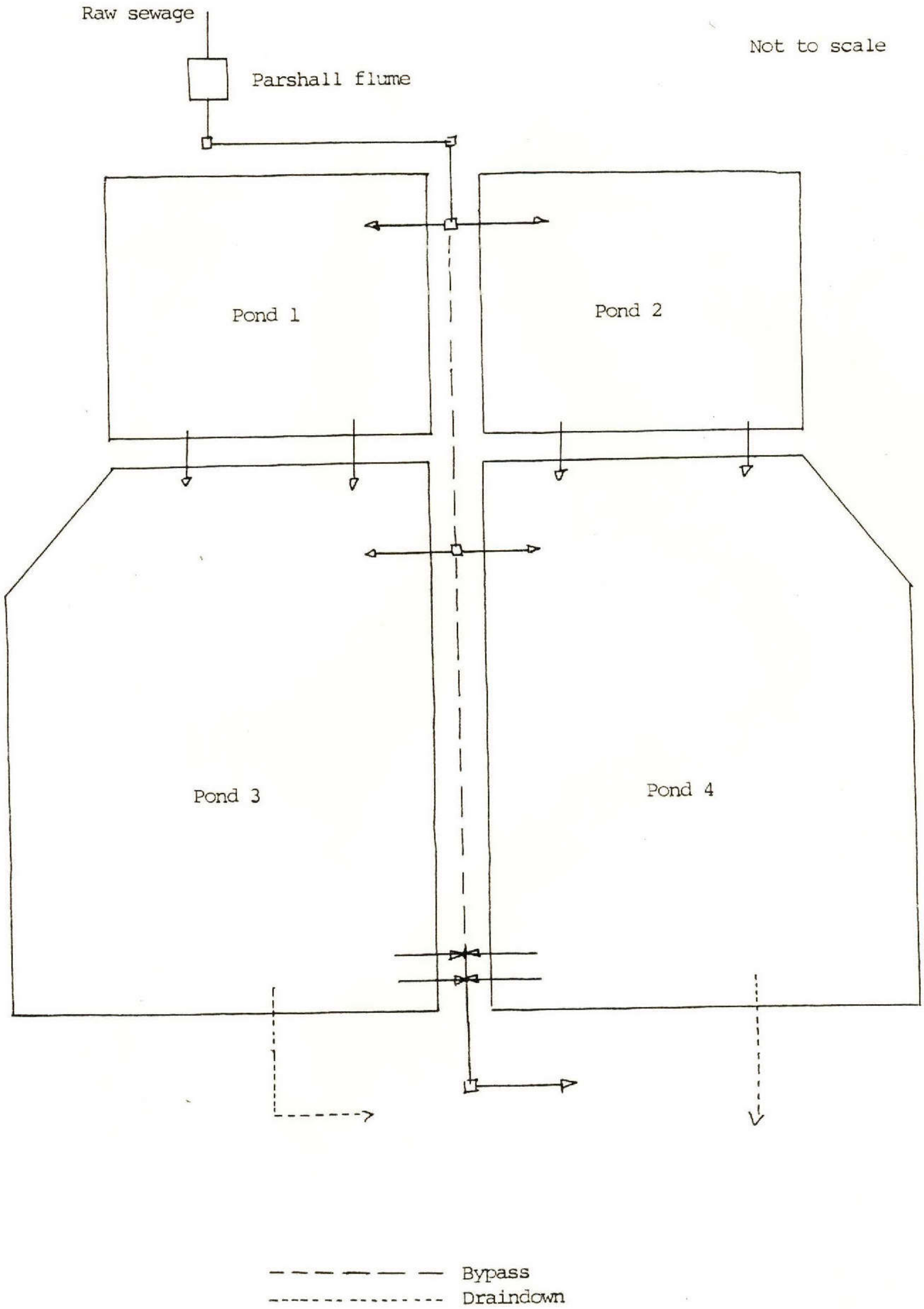
f) Complete containment of the pond effluent in the reservoir is demanded due to the area's use as a potable water catchment. Thus water from the reservoir is used all year round for irrigation. There is a problem with build up of chlorides in the soil, this is due to the ponds treating high chloride industrial effluents.

g) The effluent is not chlorinated.

9.5 Problems and Recommendations.

The high proportion of industrial effluent flowing to the ponds has caused problems with regard to rapid sludge build up in the anaerobic units and high chlorides in the final effluent. However, in spite of these problems the pond system appears to be working well under high loading rates.

SEDEROT - SCHEMATIC DIAGRAM



C2.10 YAVNEH, ISRAEL

May 24th 1981

Client: Town Council
Bank Funded.

10.1 Design.

a) No resistance to use of ponds.

b) Design based on standard loading rates using the criteria set out below.

Design Parameter		Design Assumption	Actual
Population	(1985)	16,000	12,500
Per Capita Wastewater contribution	1/c/d	108	110
Daily average wastewater flow	m^3/d	3,700	1,375*
Per Capita $B.O.D._5$ contribution	g/c	40	40
$B.O.D._5$	mg/1	770	360*
$B.O.D._5$	kg/day	2,850	495

* Industry adds 1500 m^3/day @ 500 mg/1 thus balance 2875 m^3/day @ 433 mg/1. Design assumed 2,000 mm/day from industry. The system comprises 2 No. aerated lagoons running in series.

Pond Characteristics (Design)

		Lagoon No. 1	Lagoon No. 2
Volume	m^3	27,600	27,600
Depth	m	3	3
Freeboard	m	1	1
Liquid Surface area	ha.	1.1	1.1
Side slopes		1:3	1:3
Detention time - design		7.5	7.5
- actual		9.7	9.7
Organic Loading - design	$kg/m^3/d$	0.1	
- actual	$kg/m^3/d$	0.045	
Aerators	H.P.	3 x 50	3 x 20
Power Supply	$Watts/m^3$	2.7	1.1

c) The soil is a sand, and thus a bituminous lining was used with a protective covering of sand. Losses due to percolation are small, and less than the 4-5 mm/day evaporation losses.

The embankments are protected by a layer of sandstone chips at the water surface level.

Interpond connections are via dual surface outlets without screen guards, and submerged inlets under the aerators.

Preliminary treatment is provided by a communicator at the pumping station. A parshall flume is provided at the inlet to the primary pond for flow measurement.

There is no bypass to the pond system although the effluent from pond 1 can be discharged without entering pond 2.

d) A 1.8m high chain link fence topped by 3 strands of barbed wire is provided.

e) There is no special landscaping, but erosion prevention measures have been taken by planting on external embankments. Road access is good with kurkor (cemented snadstone) roadways around ponds.

f) Lighting is provided for the access to the service building only.

g) There are no laboratory facilities.

h) Gross area of site 4.2 ha.
Net area of ponds 2.2 ha.
There is no reserved land.
The ponds are located on sand dunes 2 km from the nearest main road and 5 km from the nearest housing.

i) There is no algal harvesting or fish farming.

j) The pond effluent is disposed of to a creek some distance from the pond system. This effluent is indirectly used for irrigation by a kibbutz which takes it from the creek.

k) The itemised estimated costs at time of bidding were not available.

10.2 Bidding.

A list of bids received was not available. Bidding was carried out according to standard World Bank and Israeli practice.

10.3 Construction.

The normal range of mechanical equipment was used in construction.

The breakdown of actual capital costs for the construction of the ponds is given below. Construction was carried out in 1974 and 1975 but costs are adjusted to October 1980 prices in US dollars.

Civil Works	US$ 410,000	61%
Mechanical and Power	US$ 190,000	28%
Engineering Services	US$ 70,000	11%
Total	US$ 670,000	

Using a population of 30,000, the investment per capita is US$22.3.

No appreciable cost overuns were experienced.

10.4 Operation.

a) No special start up procedures were adopted, no particular problems were encountered in the early stages of operation.

b) The system is run by Mekorot. The staff responsible are experienced in the operation of pond systems but no organisational, operational or maintenance manuals are used.

c) Estimated operational costs are given below.

Operational costs	US$ 40,000
Power costs	US$ 60,000
Total	US$100,000

For 1 million cu.m. this comes to about 10 cents per cu.m. or assuming industry pays its share about 3.3 US$ per capita per year.

d) There is no regular pond monitoring system. The most recent results available are as follows,

January 1979	$B.O.D._5$	C.O.D.
Raw sewage	365 mg/l	740 mg/l
1st pond effluent	188 mg/l	328 mg/l
2nd pond effluent	90 mg/l	136 mg/l

There are no specific effluent standards which must be achieved. Due to the lower organic loadings than used in design only 2 of the 3 aerators in each pond are operated. A citrus factory which should have produced 50% of the inflow and 75% of influent $B.O.D._5$ would not pay a share of construction costs and hence built their own treatment plant to reduce the $B.O.D._5$ from 2,000 mg/l to 500 mg/l.

There are special facilities for dealing with periods of cold weather, effluent change, enhanced flow or cases of overload. Increases in the organic loading can be handled by use of the two unused aerators with the system operating as it is at present.

e) The implementing agency appears happy with the pond system.

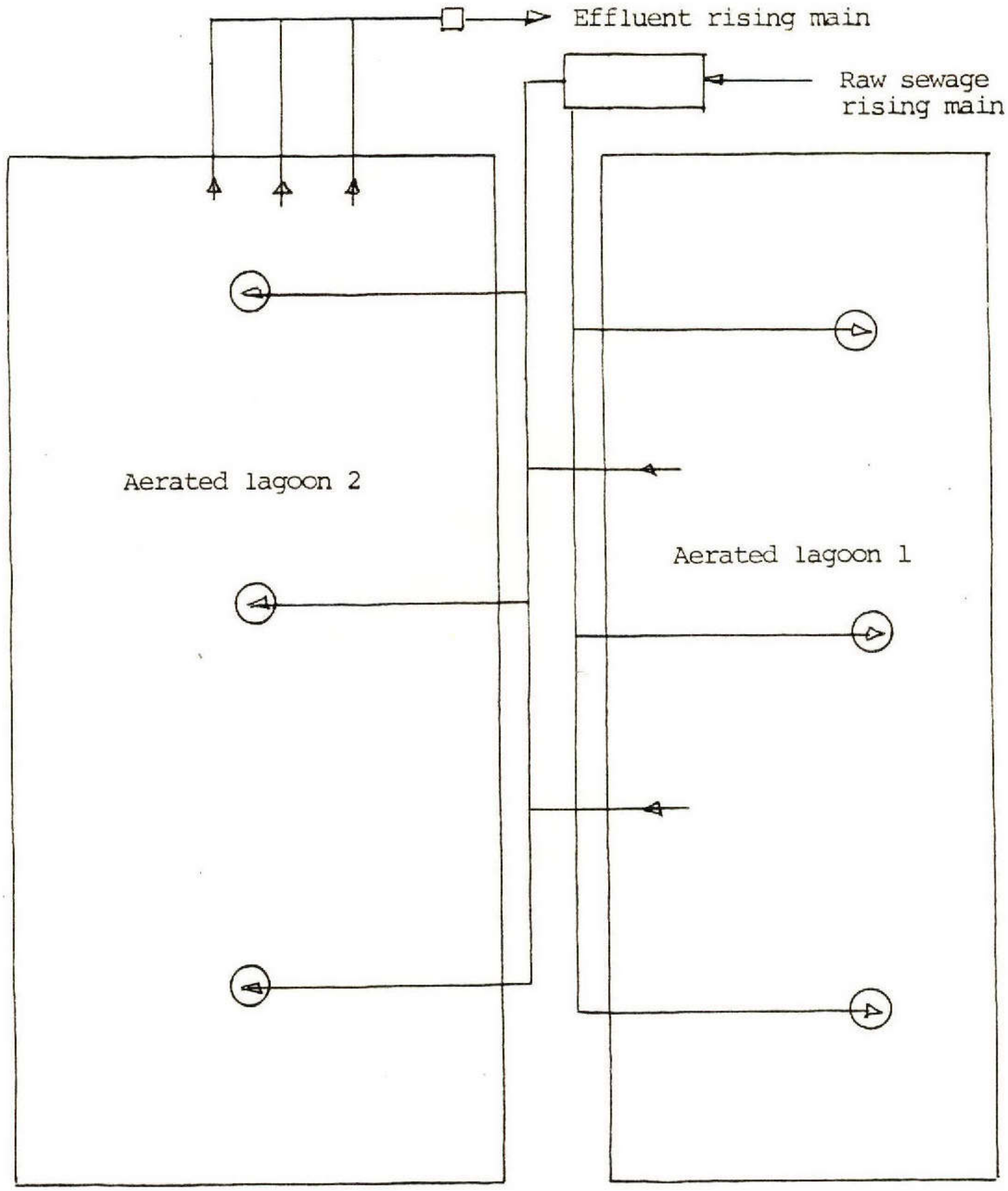
f) The effluent is not reused directly, but due to the area being used as a catchment for drinking water is piped to a stream some 2 km away for discharge.

g) There is no effluent chlorination.

10.5 Problems and Recommendations.

The internal pond embankments were overgrown with vegetation which should be removed to avoid mosquito breeding and damage to the bituminous membrane.

YAVNEH - SCHEMATIC DIAGRAM



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C2.11 ASHDOD, ISRAEL

May 26th

Client: Town Council
No Bank Project.

11.1 Design.

a) Initially some client resistance to use of ponds.

b) The basis of the design procedure used is not clear. It appears to be based on provision of a particular total detention time in the system.

Design Parameters			Design	Actual
Population		(1985)	95,000	66,000
Per Capita wastewater contribution	l/c/d		200	130
Daily average wastewater flow			19,000	8,500*
Per Capita BOD_5 contribution	g/c/d		65	50
$B.O.D._5$ of raw sewage	mg/l		325	380
Daily $B.O.D._5$ load	kg/day		6,175	3,280

* This flow rate includes 25% from industry assumed at $2m^3$ per dunam per day ($20m^3$/ha/day).

The design was originally intended for a population of 55,000 using an anaerobic pond design loading rate of 175 kg/ dunam /day (1,750 kg BOD_5/ha/day) or 0.07 kg BOD_5/m^3/day.

The system comprises four ponds in series of which one is intended to be an anaerobic pond. The pond characteristics and loadings are as follows (assuming a design population of 55,000 and the projected 95,000).

Pond Characteristics		Pond No. 1	Pond No. 2	Pond No. 3	Pond No. 4
Volume	m^3	65,000	49,000	49,000	49,000
Depth	m	2.4	1.5	1.5	1.6
Freeboard	m	1.3	1.3	1.3	1.3
Liquid surface area	ha.	3.25	3.25	3.25	3.25
Side slope		1:3	1:3	1:3	1:3

Loading rates and detention time in the primary pond are,

Population		55,000	Actual	95,000
Areal organic loading	Kg BOD_5/ha/day	1,750	1,010	1,900
Volumetric organic loading	Kg BOD_5/m^3/day	0.07	0.05	0.095
Detention time	days	5.9	7.6	3.4

c) The soil is sandy but no lining material was used. The ponds were assumed to be capable of sealing themselves.

The embankments are protected by a layer of kurkar (cemented sandstone chips) at the water surface level.

Interpond connections are via dual surface outlets with scum guard, and dual surface inlets above or at the liquid surface level.

There is no flow measuring device at the treatment plant. Preliminary treatment of the raw sewage is carried out before it is pumped to the ponds.

There is no bypass except direct discharge of influent raw sewage.

d) Fencing is now almost non existent at the plant except for a few standing posts.

e) No special planting or landscaping for erosion control has been carried out. Access is provided by good quality gravel roads round all ponds.

f) No lighting is provided.

g) There are no laboratory facilities.

h)

Gross area of site	18 ha.
Net area of ponds	13 ha.
Existing reserved land	45 ha.

The land is owned by the municipality and the ponds are sited 3.5 km from the nearest housing and 2 km from the nearest main road.

i) There is no algal harvesting or fish farming.

j) The effluent is reused for spray irrigation of cotton by a neighboring kibbutz.

k) The itemised estimated costs at time of bidding were not available.

11.2 Bidding.

The list of bids received was not available.

11.3 Construction.

No information was available on construction methodology or actual capital costs.

11.4 Operation.

a) No special start up procedures were used and no particular nuisance problems were encountered in the early stages of operation. Considerable percolation problems were, and still are, being encountered due to the siting of the ponds in an area of sand dunes on a parched clay layer.

b) The pond system is operated by a local private contractor specialising in the maintenance of sewerage and sewage treatment systems. There are no organisational or maintenance manuals.

c) There was no information available on the operational costs. A proposal to repair the fence and clean out the primary pond (10 years operation without cleaning) will cost US$20,000.

d) There is no system of regular pond performance monitoring, nor is there any record of treatment efficiency of the system. There are no regulatory standards and effluent quality appears to be poor. The maintenance was poor with exposed sludge banks, a good deal of weed growth, and some scum. Wave action was causing erosion problems on embankments not protected by vegetation. There are no special provisions for coping with enhanced flow, effluent change or overloading, and flexibility of the system is limited.

e) The town seems reasonably happy with the pond system except with the percolation problem which causes the formation of lakes around the pond system.

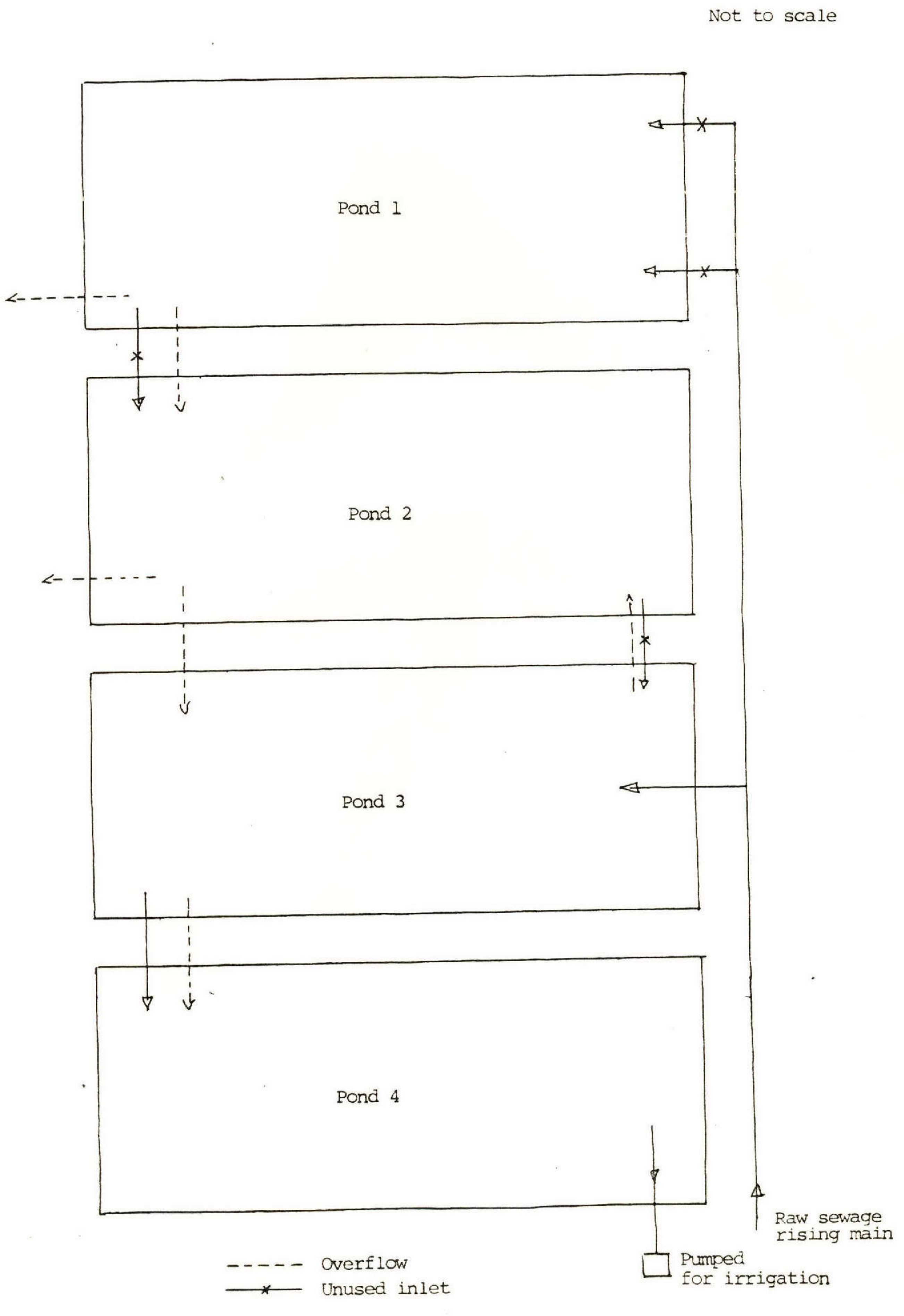
f) Effluent is reused for spray irrigation of cotton by a neighboring kibbutz who own and run the pumping station which delivers this effluent. The same station pumps the effluent into streams for discharge to the sea during winter, a service for which the municipality pays.

g) The effleunt is not chlorinated.

11.5 Problems and Recommendations.

The major problems with the system are those of overloading, excessive percolation and poor maintenance. These will be partially resolved with the proposed investment, but further work should be carried out to avoid major nuisance in the future, and maintenance should be improved.

ASHDOD - SCHEMATIC DIAGRAM



C2.12 EINSHEMER, ISRAEL

May 25th

Client: Menache Regional Council.
Project not Bank funded.

12.1 Design.

a) No resistance to use of ponds from client but from kibbutz leasing land.

b) The basis of the pond design is not known but the parameters used were as follows.

Design Parameter		Design (1980)	Actual
Population		11,000	7,000
Per capita wastewater contribution	l/c/d	90	70
Daily average wastewater flow	m^3/d	1,000	500*
Per capita BOD_5 contribution	g/c/d	45	30
$B.O.D._5$	mg/l	500	420
$B.O.D._5$	Kg/day	500	210*

* The flow also has a contribution from a neighboring army barracks and kibbutz giving a total flow of 1,000 m^3/day and total $B.O.D._5$ loading of 420 Kg/day.

The system comprises a pair of primary ponds run in parallel and three series ponds. The pond charactersitics are given below.

Pond Characteristic		Ponds 1&2	Pond 3	Pond 4	Pond 5
Volume	m^3	2 x 1,700	20,000	20,000	20,000
Depth	m	2.5	2.0	1.5	1.5
Freeboard	m	0.85	0.6	0.6	0.6
Liquid Surface area	ha	2 x 0.1	1.1	~1	~1
Side slope in		1:3	1:3	1:3	1:3
Side slope out		1:2.5	1:2.5	1:3	1:3
Detention time	days	3.4	20	20	20
Organic loading - actual					
areal	Kg/ha/day	2,100			
volumetric	$Kg/m^3/day$	0.12			
Organic loading - design					
areal	Kg/ha/day	2,500			
volumetric	$Kg/m^3/day$	0.15			

c) The ponds are constructed on a clay soil, no additional material was brought onto site for embankment construction. There is no embankment protection at the water surface level. The ponds are connected via surface outlets and sub-surface inlets; there is no bypass. There is no pretreatment and no flow measuring device. No percolation problems are experienced, losses of 5 mm/day are due to evaporation.

d) The site is fenced by a 1m high fence consisting of four strands of barbed wire on concrete posts at 4m intervals.

e) There is no deliberate landscaping or planting for erosion control. Access to recently constructed ponds 1, 2 and 3 good but unsurfaced. No access to ponds 4 and 5.

f) No lighting is provided.

g) There are no laboratory facilities.

h)

Gross area of site	4.2 ha.
Net area of ponds	3.3 ha.
Existing reserved land	0.7 ha.

The land used for the ponds is leased to the kibbutz who transfer the effluent to their irrigation reservoir. The kibbutz was unhappy at the land being used for a pond system. The system is 1.5 km from the nearest housing and 1 km from the nearest main road.

i) There is no ancillary use for fish farming or algal harvesting although the ponds 3 to 5 contain both fish and turtles.

j) The effluent is pumped to a kibbutz owned irrigation reservoir from where it is used for spray irrigation of cotton.

k) The itemised estimated costs at time of bidding were not available.

12.2 Bidding.

Information on the list of bids received was not available.

12.3 Construction.

The pond system was originally constructed in 1962 but additional ponds were added and the existing elements reconstructed in 1980. Construction/reconstruction costs using October 1980 prices were US$140,000. Assuming an eventual population served of 11,000 this represents a per capita investment of US$12.75.

Earthwork problems were encountered during contruction but these were solved by change orders to the tender. Costs incurred over and above the contract were agreed between the contractor and engineer. The major problem with the earthwork was the estimation of the amount of material to be removed in cleaning out the existing ponds and how to handle this material.

12.4 Operation.

a) There were no special start up procedures used, and no particular nuisance problems were encountered in early stages of operation.

b) The system is run by the regional council themselves. One man is responsible for the operation of the Einshemer ponds and six other plants. There are no organisation or maintenance manuals used.

c) No information was available on operational costs.

d) There is no system for the regular monitoring of pond treatment parameters. There are no regulatory standards, and due to pumping problems the ponds are currently operating with a reduced flow rate. Thus effluent quality is high and there are no problems of smell, sludge build up or scum, although weed growth is a problem on the embankment of the older ponds. Wave action has caused some erosion on the old ponds but the new ponds have not yet been affected. There are no special facilities for coping with enhanced flow, cold periods, effluent change or overload. There is some flexibility in the pond system in that the ponds may be operated in a variety of series arrangements.

e) The implementing agency appears perfectly satisfied with the pond system.

f) The effluent is reused for spray irrigation of cotton. The kibbutz from which land was taken for the ponds has found that their crop yield has increased by more than enough to compensate for the land lost. The irrigation water is taken from a 250,000 m^3 reservoir fed by the ponds.

g) There is no chlorination of the effluent.

12.5 Problems and Recommendations.

There are no major problems with the pond system except that the full loading rate has not yet been achieved due to pumping problems. Some maintenance improvement should be carried out to ensure vegetation is kept down in the ponds.

EINSHEMER - SCHEMATIC DIAGRAM

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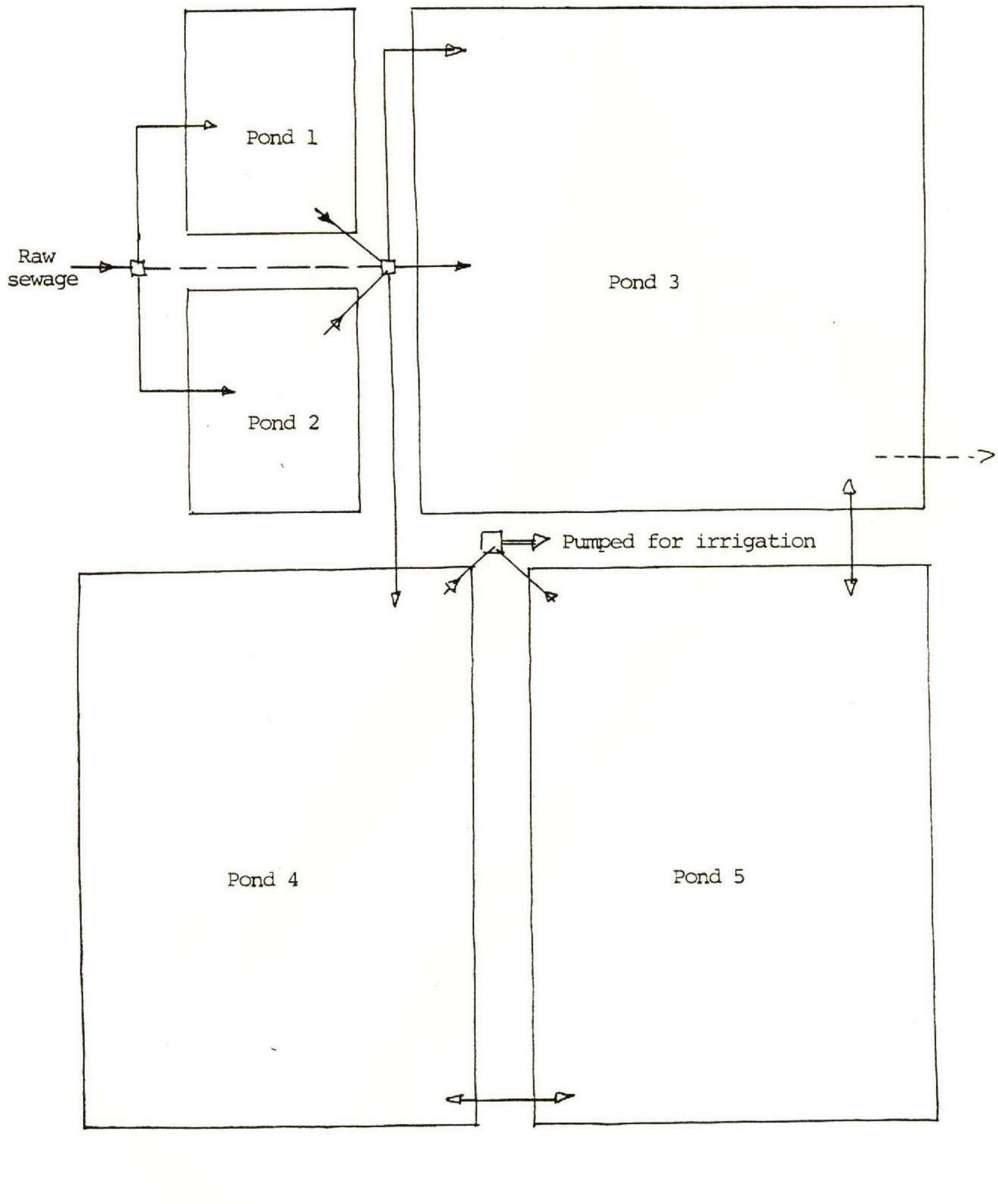


— — — Bypass

- - - - - - - - Overflow

C2.13 MIGDAL HAEMEQ, ISRAEL

May 25th

Client: Regional Authority.
Bank Funded Project.

13.1 Design.

a) There was no particular client resistance to use of a pond system.

b) The system is designed on the basis of the requirement for irrigation. However, the parameters relevant to the sewage treatment aspect of the system are given below.

Design Parameter		Design (1985)	Actual
Population		15,000	13,800
Per capita wastewater contribution	l/c/d	..	150
Daily wastewater flow	m^3/d		4,000*
Per capita B.O.D.$_5$ contribution	g/c/d		50
B.O.D.$_5$	mg/l		350
B.O.D.$_5$	Kg/day		1,500

* This includes 2,000 m^3/day from food processing industry.

In winter the sewage is highly diluted with flood water.

The characteristics of the single pond/reservoir are given below.

Pond Characteristics		Reservoir
Volume	m^3	900,000
Depth	m	7
Freeboard	m	1
Liquid surface area	ha.	12
Side slope in		1:4
Side slope out		1:2.5
Detention time	days	225
Organic Loading	Kg/ha/day	125

c) The reservoir is constructed on clay and no additional material was required to seal the embankments. There is no special protection provided at water surface level.

The inlets and outlets are submerged and influent is pumped into and effluent out of the reservoir. Pretreatment is provided at the pumping station for the inflow by a comminutor.

There is no flow measuring device although flow can be measured at the pumping station. The reservoir can be bypassed by overflow from the inflow sump to the adjacent Mizra stream bed.

There are no particular percolation problems.

d) There is no fencing.

e) Planting is provided on outside embankments to minimise erosion. There is no access road to or around the reservoir.

f) There is no lighting.

g) There are no laboratory facilities.

h) Gross area of site 15 ha.
Net area of site 12 ha.
There is no specific reserved land although more could be taken if necessary. The reservoir is located on kibbutz owned land, and was constructed by them. The municipality negotiated with the kibbutz to allow their sewage to be treated in the reservoir. The site is 2km from the nearest residential neighborhood and 1km from the nearest main road.

i) There is no algal harvesting or fish farming.

j) All the water is used for spray irrigation of a variety of crops - mainly cotton and fodder crops.

k) The itemised estimated costs at the time of bidding were not available.

13.2 Bidding.

The list of bids received and information on method of procurement were not available.

13.3 Construction.

The reservoir construction was supervised by Kibbutz Genigat who own the land on which it is constructed. Good embankment compaction was achieved using pneumatic tyred rollers. No information was available on the cost of construction or requirement for charge orders. The Bank funded the conveyance from Migdal Haemaq to the reservoir.

13.4 Operation.

a) No particular start up procedures were necessary since the reservoir was already full of flood water. No nuisance was observed in early stages of operation.

b) The system is operated by members of Kibbtuz Genigat. There are no organisation or maintenance manuals.

c) No information was available on operational and maintenance costs. Operational costs comprise mainly electricity for the pumping, maintenance costs are minimal.

d) There is no regular pond performance monitoring system. However recent qualitative and quantative data collected from the reservoir is as follows.

Oct. '80 - Jan '81	-	Green colour.	No smell.
March '81	-	Grey colour.	Slight smell.
April '81	-	Clear.	No smell.
May '81	-	Green colour.	No smell.

	Near inlet to reservoir		
Date	pH	C.O.D.	B.O.D.5
30/10/80	7.9	126	80
2/12/80	8.2	236	25
24/12/80	7.9	40	23
10/ 3/81	7.3	240	143
2/ 4/81	7.8	340	147
14/ 4/81	7.0	560	192

The embankments were overgrown with vegetation showing no sign of regular maintenance.

Total losses are little more than the 5mm/day evaporation loss. The very large volume of the ponds makes it ideal for absorbing shock loadings although otherwise the system is inflexible.

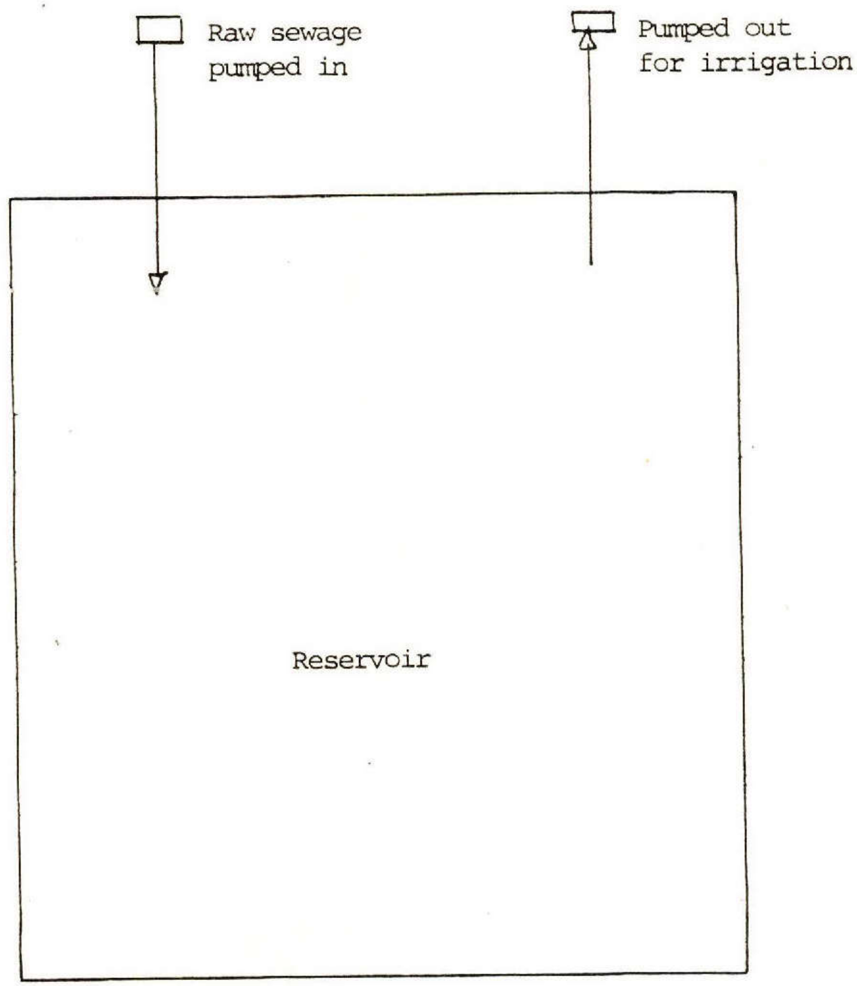
e) Use of sewage in addition to flood water in the reservoir has increased the nutrient level in the irrigation water. Kibbutz are happy with results of using this water on cotton and fodder crops.

f) There is no effluent chlorination.

13.5 Problems and Recommendations.

The only problem is one of routine maintenance, particularly in keeping down the vegetation on the interior embankments.

MIGDAL HAEMEQ - SCHEMATIC DIAGRAM



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C2.14 NAZARET ILLIT AND NAZARETH, ISRAEL

May 25th

Client: Regional Authority.
No Bank funded project.

14.1 Design.

a) There was no particular client resistance to the use of ponds.

b) No information was available on the design criteria used for the pond system. However, the actual values for the major design criteria are given below.

Design Parameter		Actual value
Population		47,000*
Per capita wastewater contribution	l/c/d	120 or 90*
Daily average wastewater flow	m^3/d	5,800
Per capita BOD_5 contribution	g/c/d	40 or 45*
$B.O.D._5$	mg/l	350
$B.O.D._5$	Kg/day	2,030

* 22,000 @ 120 l/c/d and 45 g/c/d
25,000 @ 90 l/c/d and 40 g/c/d

There is negligible contribution from industry.

The characteristics of the pond system which comprises one facultative/anaerobic pond and one reservoir are as follows.

Pond Characteristics		Pond 1	Reservoir
Volume	m^3	38,000	495,000
Depth	m	3	6.7
Freeboard	m	1	0.75
Liquid Surface area	ha.	1.2	8
Side slope		1:2.5	1:2.5
Detention time	days	6.5	85
Areal organic loading	Kg/ha/day	1,690	-
Volumetric organic loading	$Kg/m^3/day$	0.053	-

c) The soil is a clay which was used in embankment construction without additional material from off the site being required. Total losses are about 9mm per day of which less than 4m is due to percolation problems.

No embankment protection at water surface level is provided either for the pond or reservoir.

Interpond connection is via subsurface draw off and submerged inlet.

There is no flow measuring device or preliminary treatment, and the inlet structures are poorly maintained.

There is a bypass for the primary pond with the inflow directed straight to the reservoir.

d) A 2m high barbed wire fence is provided for the plant but this is in very poor repair.

e) There is no special landscaping although the exterior embankments are planted in an attempt to prevent erosion problems. Access to the pond system is good but around the ponds is poor.

f) No lighting is provided.

g) There are no laboratory facilities.

h) Gross area of site 12 ha.
Net area of ponds 9.2 ha.
Existing reserved land 12 ha.
The ponds are located on municipality owned land 1 km from the nearest housing and 0.5km from the nearest main road.

i) There is no algal harvesting or fish farming.

j) All the effluent is used for spray irrigation of cotton by a neighboring kibbutz.

k) The itemised estimated costs at the time of bidding were not available.

14.2 <u>Bidding</u>.

No information was available on the bids received.

1.43 <u>Construction</u>.

No information was available on the construction methodology used or the actual capital costs.

14.4 <u>Operation</u>.

a) No special start up procedures appear to have been used and no problems were encountered in the early stages of operation.

b) The system is operated by the kibbutz which uses the effluent for irrigation. There are no organisation or maintenance manuals.

c) No information was available on the operational costs which apart from the costs of power for pumping must be negligible.

d) There is no system for regular monitoring of pond performance. However some work has been done on the performance of the system.

Algal types in reservoir,

June	3 - 4	mg/l	Chlamydomonas
July	30 - 40	mg/l	Chlorella/Euglena
August	110 - 190	mg/l	Chlorella

Colour before June - brown/red - Thioderacae
- Chromotinium
- Sulphur bacteria

Colour after June - green

Concentration of dissolved oxygen,

June	0 - 2	mg/l
August	9 - 11	mg/l

Effluent B.O.D.$_5$ 100 mg/l of which only 20 mg/l was dissolved B.O.D.$_5$.

Some ammonia stripping was observed although no sulphides or bad smells were noticed.

Reservoir draw down during the summer was,

June	6m deep
July	3m deep
August	1m deep

No real change in effluent B.O.D.$_5$ was noticed during these peiords.

The pond and reservoir were generally poorly maintained with some odour from the primary pond and much weed growth in the primary pond and reservoir. No particular problems of sludge or scum build up were observed. There were no special opportunities for coping with enhanced flow, effluent change or overload except in the capacity of the reservoir to absorb shock loadings and increase the volume of liquid retained to 530,000 m^3 maximum.

e) The implementing agency seems happy with the pond system.

f) The effluent can be used by two kibbutz for spray irrigation of cotton, and is found to be very useful in improving productivity.

g) There is no effluent chlorination.

14.5 Problems and Recommendations.

The primary pond operates as a anaerobic/facultative pond and consequently causes some nuisance. The system should ideally be changed to provide a more heavily loaded anaerobic pond and less heavily loaded facultative pond. More care should be taken to ensure routine maintenance is carried out.

NAZERET ILLIT AND NAZARETH - SCHEMATIC DIAGRAM

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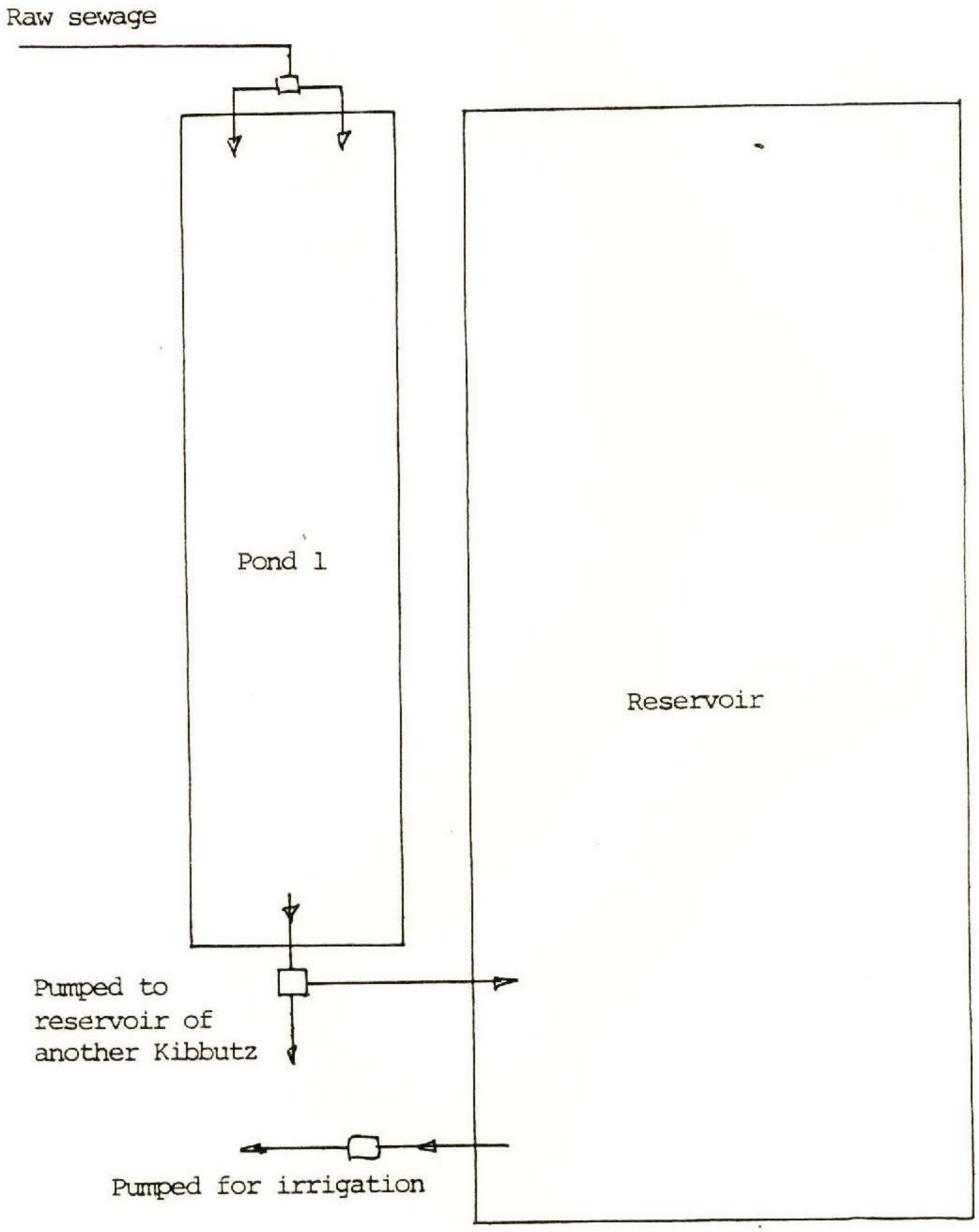


C2.15 KARMIEL, ISRAEL

May 25th

Client: Municipal Authority
Project part Bank funded

15.1 Design.

a) No client resistance to the use of ponds.

b) Little information was available on the design criteria used for the pond system, although the 14 km pipeline bringing raw sewage to the ponds is designed for 5,000 m^3/day. The actual vlaues for the main design criteria are given below.

Design Parameter		Actual value
Population (only 9,000 sewered)		13,000
Per capita wastewater contribution	l/c/d	130
Daily average wastewater flow	m^3/d	1,200
Per capita B.O.D.$_5$ contribution	g/c/d	65*
B.O.D.$_5$	mg/l	500
B.O.D.$_5$	Kg/day	600

* This figure includes 15 to 20 g/c/d from industry.

The system comprises a reservoir and two primary ponds operating in parallel. The reservoir is designed according to irrigation needs and the ponds are designed as settling ponds and insurance against problems developing in the reservoir. The pond characteristics are given below.

Pond Characteristics		Ponds 1 & 2	Reservoir
Volume	m^3	2 x 2,500	200,000
Depth	m	3.15	5.7
Freeboard	m	1.0	0.8
Liquid surface area	ha.	2 x 1.0	4
Side slope - inside		1:3.5	1:3.5
Side slope - outside		1:2	1:2
Detention time	days	4	160
Organic loading	Kg/ha/day	3,000	-
	Kg/m^3/day	0.12	-

c) The pond system is constructed on a clay soil and no additional material was required for embankment construction.

Rock protection is provided at water surface level on half of the pond system only - where the prevailing wind causes erosion problems.

There is pretreatment in the town comprising aeration for 2 to 3 days in a concrete tank before the effluent is piped under gravity 14 km to the ponds. A V notch is provided at the inlet to the pond system for flow measurement.

The simple pipe outlets and inlets to ponds are positioned 0.5 m below the liquid surface level. There is no bypass for the system.

d) There is a 1.5 m high six strand barbed wire fence on concrete posts.

e) The outside embankments are vegetation covered to help prevent erosion, and a drain is provided at the embankment toe. Good access is provided all round the ponds by a gravel road.

f) No lighting is provided.

g) There are no laboratory facilities.

h) Gross area of site 5 ha.
Net area of ponds 4.2 ha.
Existing reserved land None

The ponds are situated on kibbutz owned land and are 2 km from the nearest housing and 1 km from the nearest main road.

i) There is no algal harvesting or fish farming.

j) The effluent is reused by the kibbutz for irrigation after filtration. Spray irrigation of cotton is carried out, and chick peas are shortly to be irrigated using the effluent.

k) The itemised estimated costs at time of bidding were not available.

15.2 Bidding.

The list of bids received was not available. The delivery main was funded by the World Bank although the municipality funded the construction of the ponds under a separate contract under the Israeli Sewerage Project.

15.3 Construction.

No information was available on construction methodology although mechanical construction methods were used.

The total cost of the delivery main and pond system was US$ 120,000. With the current population served this represents a cost per capita of US$ 100 although using the project population this reduces to US$ 40 per capita.

15.4 Operation.

a) No special start up procedures were used and no particular problems were encountered in the early stages of operation.

b) The kibbutz operates the system. There is no staff training, and no organisation or operation and maintenance manuals.

c) There was no information on operational costs, which apart from those associated with pumping for irrigation, are small.

d) There is no pond performance monitoring system although some treatment information is given below.

August 1980	BOD_5 at reservoir inlet	89 mg/l
July 1980	BOD_5 in reservoir	40 mg/l
June 1980	BOD_5 of raw sewage	213 mg/l
	BOD_5 of first pond effluent	169 mg/l

The pretreatment provides approximately 40% BOD_5 removal.

The effluent has recently been approved for use as irrigation water for chick peas although there is no regulatory effluent standard.

Some scum was observed on the primary pond (one of the two anaerobic ponds was not in use). No problems of weed growth sludge build up or odours were observed.

No percolation problems are encountered, losses, almost totally due to evaporation, amount to 5 mm per day.

The large reservoir volume allows enhanced flow, overloads, etc. to be absorbed. The system is not particularly flexible otherwise.

e) Both the kibbutz and the municipality appear satisfied with the pond system.

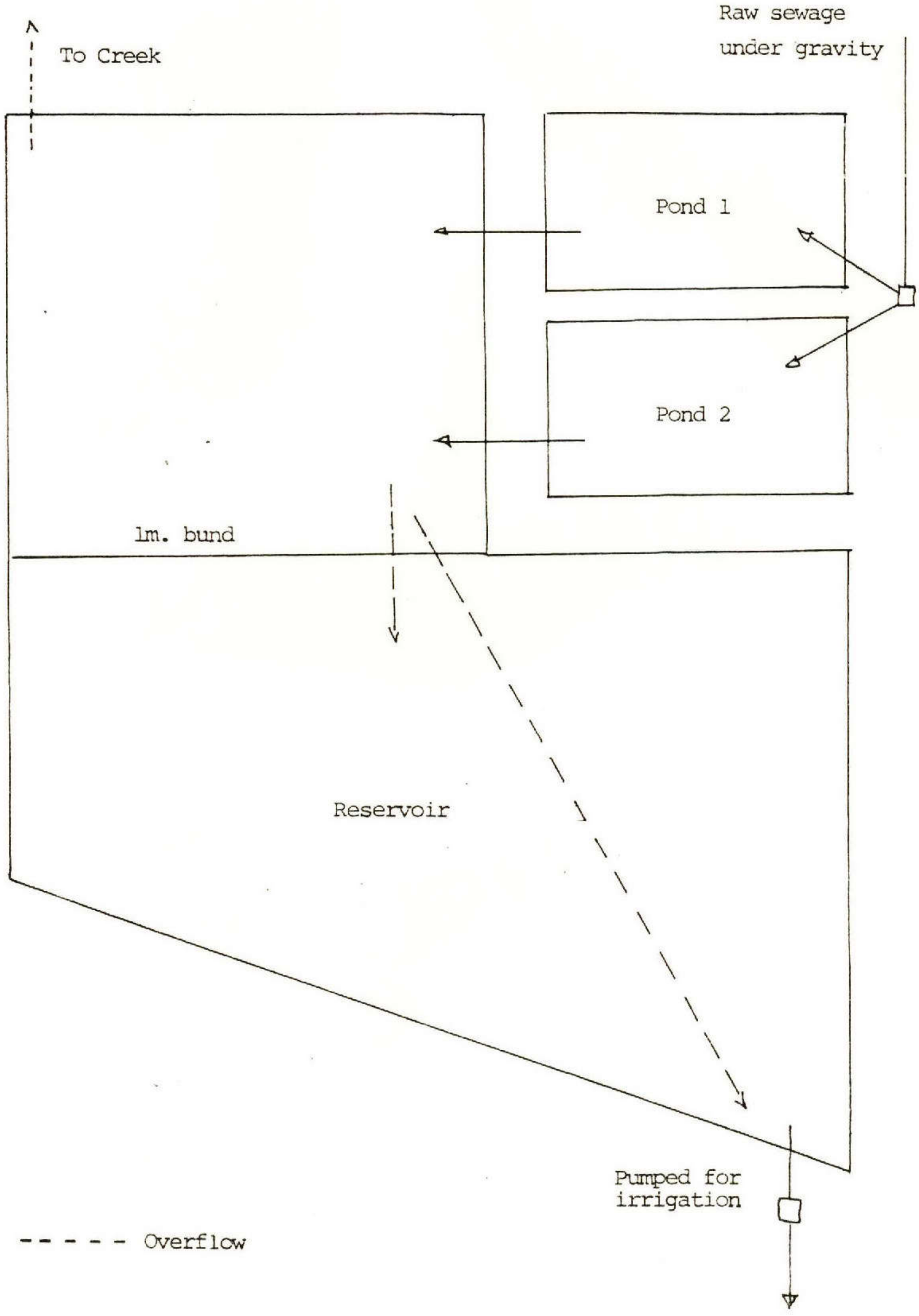
f) The kibbutz finds increased cotton yields result from irrigation with effluent, and hope to repeat this with chick peas following approval from the Ministry of Health.

g) There is no chlorination of the pond effluent which is discharged to a creek only when not required for irrigation.

15.5 Problems and Recommendations.

There could be some improvement in the general maintenance of the pond system.

KARMIEL - SCHEMATIC DIAGRAM



C2.16 SHELOMI, ISRAEL

May 25th

Client: Regional Council
Project part bank funded.

16.1 Design.

a) There was no client resistance to the use of ponds.

b) The design of the aerated lagoons was carried out on an empirical basis. The reservoir is designed to satisfy irrigation needs.

Design Parameters		Design assumption	Actual
Population		7,200	2,600
Per capita wastewater contribution	l/c/d	130	115*
Daily average wastewater flow	m^3/d	1,680+	1,000
Per capita $B.O.D._5$ contribution	g/c/d	40	40*
$B.O.D._5$	mg/l	650	400
$B.O.D._5$	Kg/day	1,092	400

\+ Meat plant contributing 650 m^3/day.

* Balance assumed 550 m^3/day from meat processing plant @ 500 mg/l
300 m^3/day from town @ 300 mg/l
150 m^3/day from kibbutz @ 350 mg/l

The system comprises two aerated lagoons and one reservoir.

Pond Characteristics		Pond 1	Pond 2	Reservoir
Volume	m^3	4,000	10,000	330,000
Depth	m	3.6	3.6	6.5
Freeboard	m	1.0	1.0	1.0
Liquid surface area	ha.	0.12	0.32	5
Side slope - in		1:3	1:3	1:3
- out		1:2.5	1:2.5	1:3
Detention time - design	days	2.4	6	196
- actual	days	4	10	330
Loading rate (volumetric)				
- design	$Kg/m^3/d$	0.16	-	-
- actual	$Kg/m^3/d$	0.1	-	-
Aerators	Hp	2 x 15	2 x 15	-
Power	$Watt/m^3$	6.0	2.4	-

A firm of consultants were employed to review sewage treatment alternatives for Shelomi. The options considered were,

i) Waste stabilisation pond system with primary facultative unit loaded at 130 Kg $B.O.D._5$ /ha/day and maturation ponds.

ii) Waste stabilisation pond system with recirculation enabling primary facultative unit to be loaded at 230 Kg $B.O.D._5$/ha/day.

iii) Aerated lagoons using a smaller area than i) and ii) but with additional maintenance costs.

Option iii) was chosen for reasons of independence from climate and smaller land requirement. No option which included anaerobic ponds was considered.

c) The soil is clayey with some gravelly lenses. Although no lining of the ponds or reservoir was originally provided, leakage problems have caused the aerated lagoons to be lined and the reservoir is currently being lined with plastic sheeting.

The embankments are protected by ungrouted rock rip rap at the water surface level.

There is no pretreatment or flow measuring device at the treatment plant itself. Parshall flume provided but not working at time of visit.

Inlets are positioned close to the bottom of the ponds and reservoir, outlets are at the surface and are provided with scum guards.

A bypass is provided for pond 1 and to allow pond 1 effluent to be discharged into a neighboring creek. There are no facilities for pond draw down.

d) A 2m high chain link fence topped by 3 strands of barbed wire surrounds the site. Tubular steel fence posts are provided at 3.5 m intervals.

e) There is no deliberate planting although the external embankments are vegetation covered. Good access is provided to and around the aerated lagoons on gravel roadway. Access to the reservoir is not yet complete.

f) There is no lighting.

g) No laboratory facilities are provided.

h)

Gross area of site	10 ha
Net area of ponds	5.5 ha
Existing reserved land	None

The ponds are constructed on kibbutz land and are 1 km from the nearest main road and 1 km from the closest housing.

i) There are no ancillary uses of the ponds such as algal harvesting or fish farming.

j) The final effluent is planned for reuse for irrigation by the kibbutz. However, due to very large percolation losses resulting in the current lining of the ponds, no effluent has yet been obtained from the ponds. The flat demand curve for irrigation water in this area has meant that a relatively small reservoir can be used. It is planned to irrigate cotton and banana.

k) The itemised estimated costs at time of bidding were not available.

16.2 Bidding.

The list of bids received was not available. The pond system was financed by the Ministry of Trade and Commerce. The electro-mechanical component came under the World Bank loan.

16.3 Construction.

No information was available on construction methodology except that mechanical excavation was used.

The aerated lagoons were constructed during 1975 and 1978, and the costs adjusted to give October 1980 prices are given below,

Civil Engineering	US$ 670,000	74%
Mechanical and Electrical	US$ 130,000	14%
Engineering Services	US$ 110,000	12%
Total	US$ 910,000	

Assuming a final population equivalent (including industry) of 15,000, this represents a per capita investment of US$ 59. These costs include for the lining of the aerated lagoons and no particular problems were encountered as regards cost overruns, or estimates and bids.

16.4 Operation.

a) There were no special precautions taken during start up. There were no reports of nuisance during early stages of operation.

b) The Regional Council hires one operator from a private contractor who is responsible for maintaining the system including the aerators. His duties are largely as technician looking after the electro mechanical components. There are no organisation or maintenance manuals except those associated with the mechanical equipment.

c) There was no information on the operational costs. Under normal conditions these would comprise mainly the power consumed for the aeration. Since none of the aerators was functional at the time of the visit, this presumably cuts down the operational cost of the plant!

d) There is no pond performance monitoring system. In view of the non-operation of all aerators at the time of the visit, and the fact that the reservoir is being lined, the treatment achieved is likely to be poor. Observation of the influent suggested a high BOD_5 concentration. The effluent still appeared to have a high BOD_5 concentration.

Since the aerated lagoons are lined, little percolation loss is experienced; total losses mainly due to evaporation are about 5 mm per day. There appear to be no particular problems with scum, sludge or weed growth when the system is functioning normally. There are no special facilities for coping with enhanced flow, overloading or effluent change, although there appears to be some spare capacity in the aeration, and the reservoir provides a good buffer against overload.

e) The regional council seems satisfied with the pond system although the kibbutz plans for irrigation with the effluent are being frustrated by the mechanical breakdown of the aerators and lining of the reservoir.

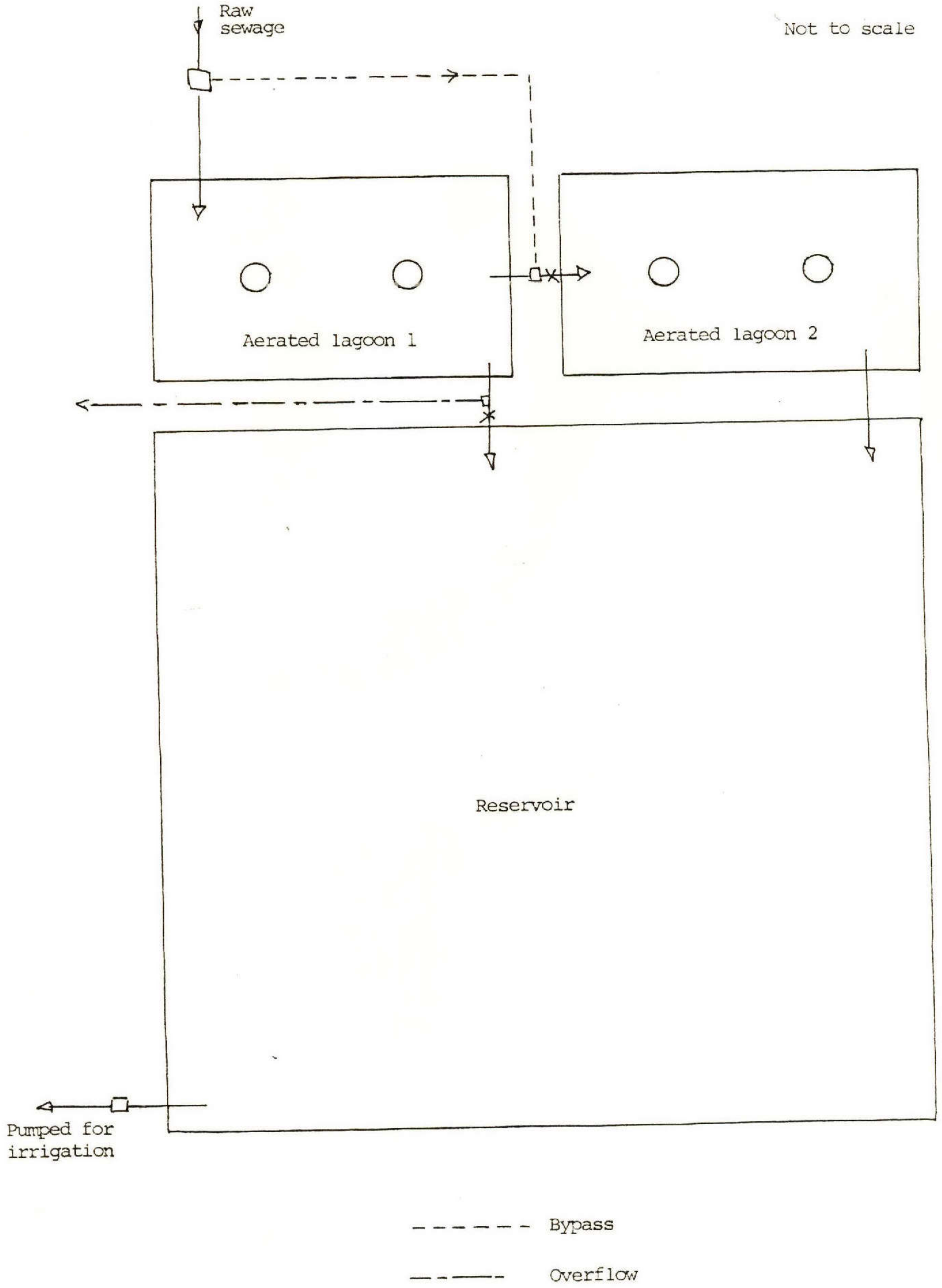
f) As yet no experience has been gained in the reuse of the effluent.

g) There is no chlorination.

16.5 Problems and Recommendations.

Considerable precolation problems have been encountered due largely to the pond system having been constructed on an old river bed. This is not to be advised and the price has been paid in this case with the need to line the ponds and reservoir. Other major problems are associated with the aerators which frequently break down and appear to be highly corroded. The problem here appears to be more one of aerator manufacture - a poor choice of aerator was made.

SHELOMI - SCHEMATIC DIAGRAM



C2.17 KIRIYAT GAT, ISRAEL

May 26th

Client: Town Council. Pond system rehabilitation only funded by World Bank.

17.1 Design.

a) There was originally no client objection to the use of ponds for sewage treatment. However, a Bank funded proposal to completely redesign ponds was thrown out by the Town Council due to local objection on the amount of money to be spent on the system. Consequently only the cleaning and rehabilitation of the existing ponds was undertaken.

b) The pond system was designed 20 years ago and information on the design assumptions was not available. However, current values for the design criteria are given below,

Design Criteria		Actual value
Population		26,000
Per capita wastewater contribution	l/c/d	100
Daily average wastewater flow	m^3/d	4,500*
Per capita BOD_5 contribution	g/c/d	36
$B.O.D._5$	mg/l	210*
$B.O.D._5$	Kg/d	1,000

* This includes approximately 2,000 m^3/day from a textile factory.

The system comprises four ponds of which three are operated in series, with the fourth in parallel with the second of the series. The pond characteristics are given below.

Pond Characteristics		Pond No 1	Pond No 2	Pond No 3	Pond No 4
Volume	m^3	8,000	6,000	11,000	7,300
Depth	m	2.0	1.5	1.2	1.2
Freeboard	m	1.0	1.0	1.0	1.0
Liquid surface area	ha	0.44	0.46	1.04	0.91
Side slope		1:2.5	1:2.5	1:2.5	1:2.5
Detention time	days	1.8	1.3	2.5	1.6
Organic Loading					
Kg BOD_5/ha/day		2,270	-	-	-
Kg BOD_5/m^3/day		0.125	-	-	-

c) The ponds are constructed on an area of clay soils - no additional impermeable material was required. There is no lining of ponds or embankment protection at the water surface level. The embankments are badly eroded at the water surface level.

The primary pond has three submerged inlets, the second pond 2 and the others one. All ponds are provided with surface outlets, the water from ponds 3 and 4 is pumped directly for irrigation.

There is no preliminary treatment or flow measurement and the ponds are not provided with bypasses or drain down facilities.

d) The previously existing fencing is now almost entirely broken down.

e) There is no landscaping, the embankments are effectively sprayed against weed growth. There is vehicular access around the ponds, although there is no road surfacing.

f) there is no lighting.

g) There are no laboratory facilities.

h) Gross area of site 5.00 ha.
Net area of ponds 2.85 ha.
Existing reserved land 10 ha.
The ponds are constructed on municipally owned land 1.5 km from the nearest housing and 0.1 km from the nearest main road.

i) There is no algal harvesting or fish farming.

j) The effluent is reused by several kibbutz for irrigation. This is controlled by a users authority. Most of the effluent is used for spray irrigation of cotton.

l) Itemised costs at time of bidding were not available.

17.2 Bidding.

A completely new pond system was put out to tender, but this scheme was rejected by the municipality after local complaints. No information was available on the bidding of the cleaning and rehabilitation work which was undertaken.

17.3 Construction.

No information was available on the construction of the original pond system or on the method used for cleaning and rehabilitation.

Approximately 3,000 cu.m. of sludge was removed from the first pond after more than 10 years operation. The pond cleaning cost US$ 12,000, or about 30 US¢ per population equivalent served.

17.4 Operation.

a) It is not known whether there were special procedures used in the original commissioning of the ponds. None were used following the rehabilitation. There was already an odour problem when the ponds were cleaned, it is not known whether the cleaning helped to reduce odours since there is currently some odour nuisance from the ponds.

b) The pond system is operated by the kibbutz users authority although it should strictly be operated by the municipality. There is or has been no training and there are no organisational or maintenance manuals.

c) No information was available on maintenance costs which apart from power consumed in pumping for irrigation, must be minimal.

d) There is no existing or planned pond monitoring system. Some data obtained recently showed the following,

		BOD_5 mg/1	COD mg/1
Inflow	Textile factory	120	800
	Municipality	280	450

Previous results showed.

1977	average raw sewage	200	560
1980	average raw sewage	209	635

The ponds appear to be heavily overloaded as facultative ponds, with only the first pond loaded heavily enough to allow it to function effectively as an anaerobic pond, for which it is really too shallow anyway. There is no algal growth in any of the ponds which may be due to a combination of the heavy loading rate and poor nutrient balance due to the high C.O.D. levels. Several of the ponds have exposed sludge, and about 50% of the first pond is covered with scum. The pond system has no flexibility to deal with cases of overloading, effluent change or enhanced flow. Pond four is provided with baffles in an attempt to achieve a more efficient hydraulic regime, although there is no indication as to whether or not this is achieved.

e) The municipality is unhappy with the odour nuisance form the ponds but seem unprepared to spend the money to have the problems put right.

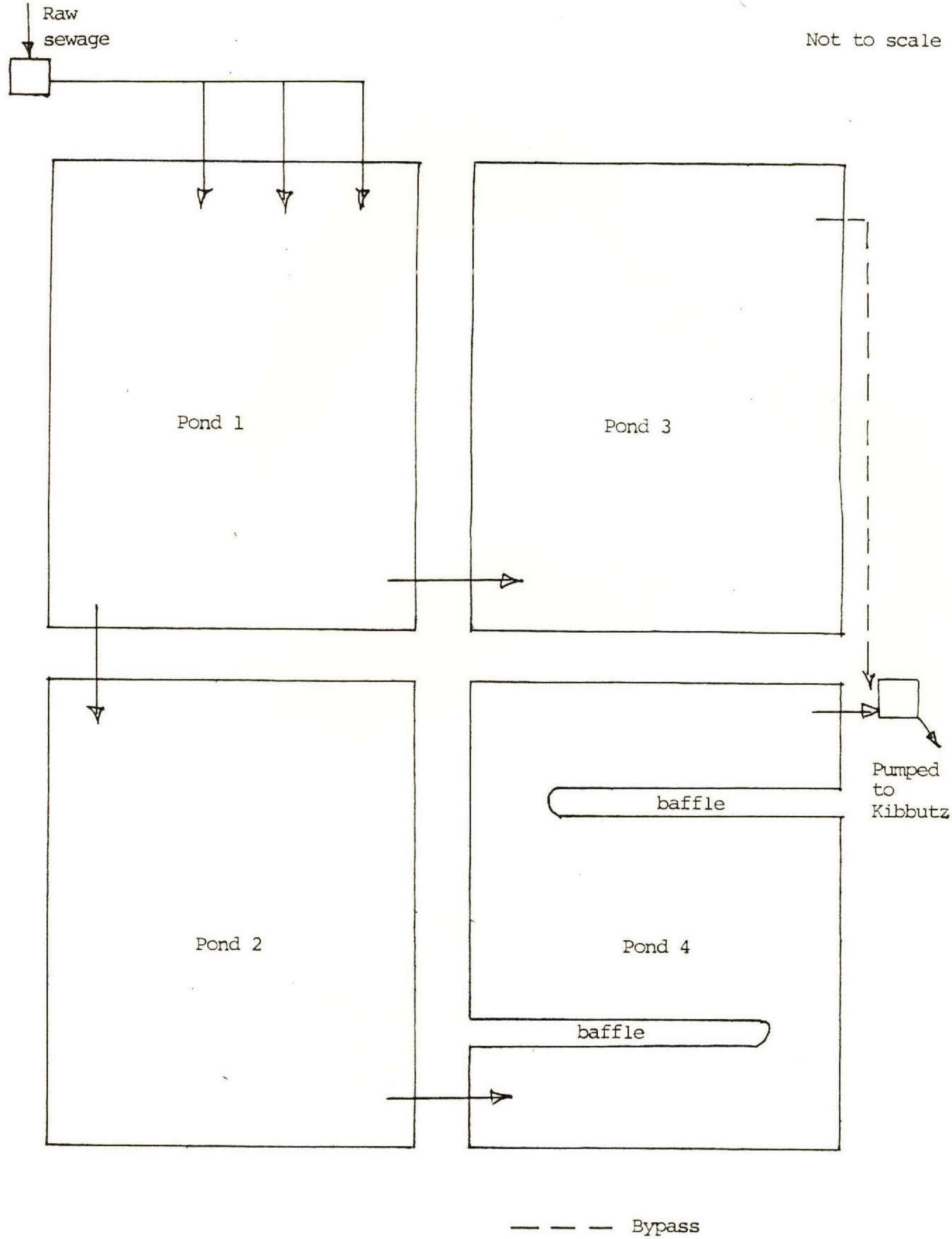
f) All the effluent is pumped to irrigation reservoirs owned by the kibbutz, from where it is used to spray irrigate cotton after further retention.

g) There is no effluent chlorination.

17.5 Problems and Recommendations.

The pond system is grossly overloaded and cannot be improved without enlargement. This should take the form of deepening two of the ponds so that they can be made effective anaerobic units, joining the two others to make a facultative pond with a larger detention time, and adding a further unit to improve effluent quality further. It may also be necessary to provide some form of pretreatment for the textile waste water to bring down the C.O.D. and improve the nutrient balance of the raw sewage.

KIRIYATGAT - SCHEMATIC DIAGRAM



C2.18 OFAQIM, ISRAEL

May 26th

Client: Town Council
Funded by World Bank.

18.1 <u>Design.</u>

a) There was no client objection to the use of a pond system for wastewater treatment.

b) The pond system design appears to have been based on empirical loading rates. The design assumptions and actual values for design parameters are given below.

Design Parameter		1985 Design Assumption	Actual
Population		15,000	12,500
Per capita wastewater contribution	l/c/d	150	120
Daily average wastewater flow	m^3/d	2,850	1,650
Per capita BOD_5 contribution	g/c/d	67	40
BOD_5	mg/l	447	333
BOD_5	Kg/day	1,200	500

The flow rate was measured during 1980 at 1600 m^3/day.

The raw sewage includes about 20% industrial/commercial contribution at a BOD_5 of 400 mg/l.

The pond system comprises 3 primary anaerobic ponds of which only one is currently being used, and 2 facultative ponds of which only one is currently being used. The pond characteristics are given below,

Pond Characteristic		Ponds 1,2	Pond 3	Pond 4	Pond 5
Volume	m^3	2 x 8,050	18,400	37,500	37,500
Depth	m	3.5	3.5	1.8	1.8
Freeboard	m	0.8	0.8	0.8	0.8
Liquid surface area	ha.	2 x 0.23	0.525	2.4	2.4
Side slope		1:3	1:3	1:3	1:3
Detention time design	days	10	10	13	13
actual	days	-	11	-	22
Organic loading design					
- areal	Kg/ha/d	1,200	1,200	-	-
- volumetric	$Kg/m^3/d$	0.04	0.04	-	-
Organic loading actual					
- areal	Kg/ha/d	-	952	-	-
- volumetric	$Kg/m^3/d$	-	0.027	-	-

Facilities are provided for recirculation between ponds 5 and 4. The recirculation is not used, and the light loading rate means only ponds 3 and 5 are operated at present.

c) The ponds are constructed in an area of clayey silt which was used in the construction of embankments without need for additional material. Careful compaction was required on the embankments using vibrating rollers.

No embankment protection is provided at water surface level.

Multiple inlets are provided for ponds 1, 2 and 3 with single inlets from each of these to pond 4 and dual inlets to pond 5. Surface draw off is used at the outlets for each pond.

There is preliminary treatment at the pumping station, no flow measuring device is provided at the ponds. A bypass for pond 4 is provided to allow effluent form pond 3 to flow directly to pond 5.

d) The site is fenced by a 2m high barbed wire fence on concrete posts.

e) There is no special landscaping although the ponds are surrounded by vegetation. Good access is provided by a 6m wide road of river gravel around the pond embankments.

f) There is no lighting.

g) There are no laboratory facilities.

h) Gross area of site 7.5 ha.
Net area of ponds 5.8 ha.
There is no reserved land.
The ponds are constructed on municipality owned land 1 km from the nearest housing and 1 km from the nearest main road.

i) There is no algal harvesting or fish farming.

j) The effluent is used by a private farmer for irrigation of cucumber and tomato seeds and cotton.

k) The estimated costs at time of bidding were not available.

18.2 Bidding.

The list of bids received was not available. Procurement was in keeping with the standard practice of prequalification and tendering laid down by the World Bank for the Israeli Sewerage Project.

18.3 Construction.

No information was available on the construction methodology used except that the embankments required careful compaction with vibrating rollers. Tight supervision of earthworks was operated since problems were encountered with the earthworks. There were no cost overruns although the unforeseen contingencies were utilised.

Construction costs adjusted to October 1980 prices in US$ are given below.

Civil Works	360,000 US$	82%
Mechanical and Power	35,000 US$	8%
Engineering Services	45,000 US$	10%
Total	440,000 US$	

18.4 Operation.

a) No special start up procedures were used, there were no reports of nuisance in the early stages of operation.

b) The system is operated by an employee of the farmer who pays the municipality for use of the effluent. There is no training of operators and there are no organisation or maintenance manuals.

c) There was no information on operational costs which apart from pumping for irrigation must be minimal. Further operation costs would be incurred were the recirculation to be operated.

d) There is no existing or planned pond monitoring system. Effluent quality appears good although there are no regulatory standards. The single operational anaerobic pond is part scum covered and has a slight odour. Effluent from here is delivered directly to pond 5 which operates effectively as a facultative/maturation pond. The system is only partially utilised at present and the spare capacity offers considerable flexibility in pond operation at present. The recirculation is not operated at the moment, but this adds more versatility to the system. Under current conditions additional ponds could be operated to overcome effluent change, overloading or increased flow. As the flow rate increases the recirculation will provide the means for coping with shock loadings. Losses from the system are small and are mainly due to evaporation which averages 6.4 mm per day.

e) The implementing agency seems satisfied with the pond system.

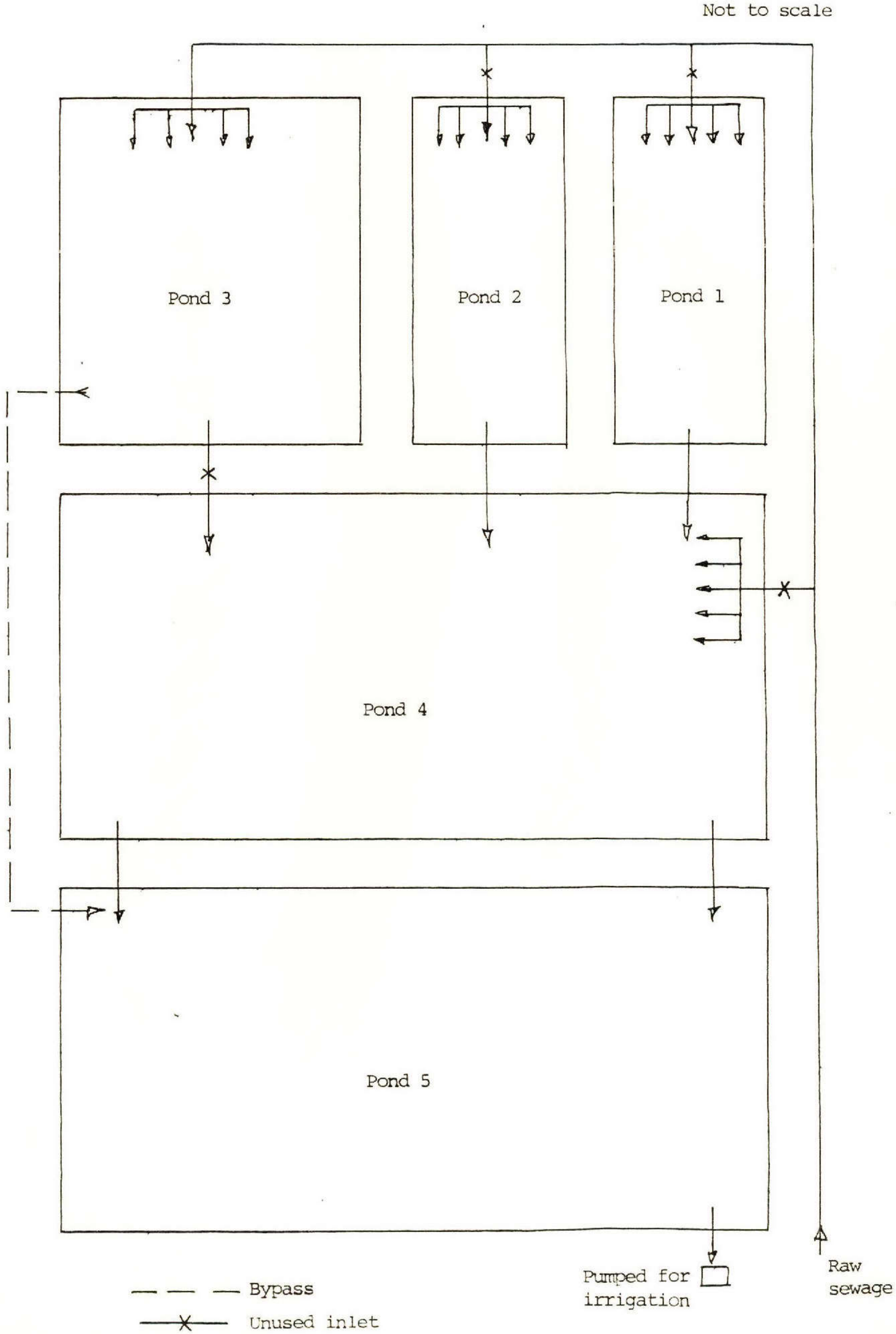
f) The effluent is reused by a private farmer for spray irrigating cotton and tomato seeds, and drip irrigating cucumbers. No special problems are encountered with use of the effluent for irrigation, and 50 ha of land is effluent irrigated.

g) There is no chlorination of the effluent.

18.5 Problems and Recommendations.

The system has no particular problems. The anaerobic pond is quite lightly loaded, and it is likely that as the flow builds up and loading rate increases so the slight odour nuisance will disappear.

OFAQIM - SCHEMATIC DIAGRAM



C2.19 BEER SHEVA, ISRAEL

May 26th

Client Town Council
No Bank Project or any investment since 1967.

19.1 Design.

a) The town does not appear to have objected to the pond system when it was constructed in 1966.

b) The original design assumptions were not available, but those used in a proposal for improvements in 1971 which were not implemented, are given below,

Design Parameter		Design Assumption (1985)	Actual
Population		140,000	110,000
Per capita wastewater contribution	l/c/d	165	145
Daily average wastewater flow	m^3/d	25,400	16,000
Per capita BOD_5 contribution	g/c/d	60	44
BOD_5	mg/l	367	304
BOD_5	Kg/d	9,230	4,850

These figures assume that 10% of the total flow is contributed by industry.

The original pond design was based on empirical loadings and comprises a system of four anaerobic/facultative ponds, two facultative ponds and two maturation ponds and a reservoir. The pond characteristics are given below,

Pond Characteristics		Ponds 1to4	Ponds 5&6	Ponds 6&7	Reservoir
Volume	m^3	4 x 22,500	2x 36,000	2x 28,000	437,000
Depth	m	2.5	1.5	1.5	6
Freeboard	m	1	1	1	0.7
Liquid surface area	ha	4 x 1	2 x 2.85	2 x 1.85	8
Side slope inside		1:3	1:3	1:3	1:3.5
Side slope outside		1:3	1:3	1:3	1:3.5
*Detention time					
design	days	3.5	2.8	2.2	17
actual	days	2.8	4.5	3.4	27
*Organic loading,					
design - areal	Kg/ha/d	2,300	-	-	-
-volumetric	$Kg/m^3/d$	0.102	-	-	-
actual - areal	Kg/ha/d	2,425	-	-	-
-volumetric	$Kg/m^3/d$	0.107	-	-	-

*These figures are based on the design figures with all the ponds operational and the actual figures assuming only ponds 2 and 3 operating which is the current situation.

A scheme in 1971 to construct aerated lagoons for the Beer Sheva wastewater treatment system was rejected on grounds of cost.

c) The ponds are constructed on clay/silt Loess and are not lined. There is no embankment protection at the water surface level.

The inlets and outlets are shown below, surface outlets and subsurface inlets are used.

Pond	Inlets	Outlets
1 to 4	each 3 No.	3 No.
5 & 6	each 6 No.	3 No.
7 & 8	each 1 No.	3 No.
Reservoir	1 No.	1 No.

Pretreatment is provided at the pump house in the town and comprises a screen and comminutor. A parshall flume is positioned before the comminutor for flow measurement. Splitters are provided to divide the flow once it reaches the pond site.

There is a complete bypass for the system and there are facilities to allow draw down of the ponds.

Losses due to percolation are not significant.

d) The site is protected by a 6 strand 1.8m high barbed wire fence on concrete posts.

e) There is no landscaping although the pond system is overgrown with vegetation. Access to and around the ponds is provided by dirt roads.

f) There is no lighting.

g) There are no laboratory facilities.

h)

*Gross area of site	16	ha.
*Net area of ponds	13.4	ha.
Existing reserved land	4	ha.

The ponds are located on municipality owned land to the South East of the town. The system is 2 km from the nearest housing and 1 km from the nearest main road.

*This excludes the land used for the 8 ha reservoir which is kibbutz owned.

i) There is no algal harvesting or fish farming.

j) All the effluent is used by the kibbutz for spray irrigation of 700 ha of cotton, wheat and alfaalfa.

k) Itemised estimated costs at time of bidding were not available.

19.2 Bidding.

No information was available on the bids received or on the procurement process used for construction of the pond system.

19.2 Construction

No information was available on the construction methodology, although mechanical methods were used. There was no information on unit costs, contract cost or need for charge orders.

19.4 Operation.

a) There do no appear to have been any special procedures adopted in starting up the ponds, nor was any nuisance caused in the early stages of operation.

b) The system is operated by the Kibbutz who use the effluent for irrigation. There is no training and there are no organisation or maintenance manuals.

c) No information was available on operational costs which comprise mainly energy for pumping for irrigation,and occasional weed spraying.

d) There is no existing or planned pond monitoring system. Some data has been collected for the reservoir concerning the algae and bacteria, and this is presented below,

Algae in reservoir : greens - Chlorella, Micractinium
bluegreens - Spirulina, Chlorococcum

Algae in maturation pond effluent - green - Chlamydomonas

Total bacterial counts,	Raw sewage	10^6-10^7
	Maturation pond effluent	10^6
	Reservoir	10^5-10^6

Also observed were photosynthetic sulphate bacteria of the Chloromonas and Rhodopseudomonas species.

The rate of production of Chlorophyl A in the reservoir was found to vary between 0.3 and 1.8 mg/l/hr.

Odour problems from the system have led to the removal of ponds 1 and 4 from service to encourage higher loading rates and thus better conditions for anaerobic treatment in ponds 2 and 3. The system suffers form odour nuisance, fly nuisance and excessive weed growth in the ponds. No exposed sludge was evident but scum mats covered a high proportion of the surface of primary ponds. The system is highly overloaded and consequently the capacity to absorb shock loadings or cope with effluent change or increased flow rate is limited. Operation is flexible inasmuch as a bypass is provided for the entire system.

e) The implementing agency finds the pond system an extremely cheap solution to wastewater disposal problems but is not happy with the nuisance problems.

f) The effluent is used by the kibbutz in exchange for their operation of the system. A small reservoir can be used because of the flat demand curve generated by irrigating three crops,

Summer crop	- cotton	- 300 hectares
Winter crop	- wheat	- 250 hectares
Buffer crop	- alfa alfa	- 150 hectares

Alfa alfa will absorb a lot of water or survive on very little depending on other irrigation needs. Irrigation is carried out in six applications per month giving 400mm total irrigation (evaporation averages 5mm/day).

g) There is no effluent chlorination.

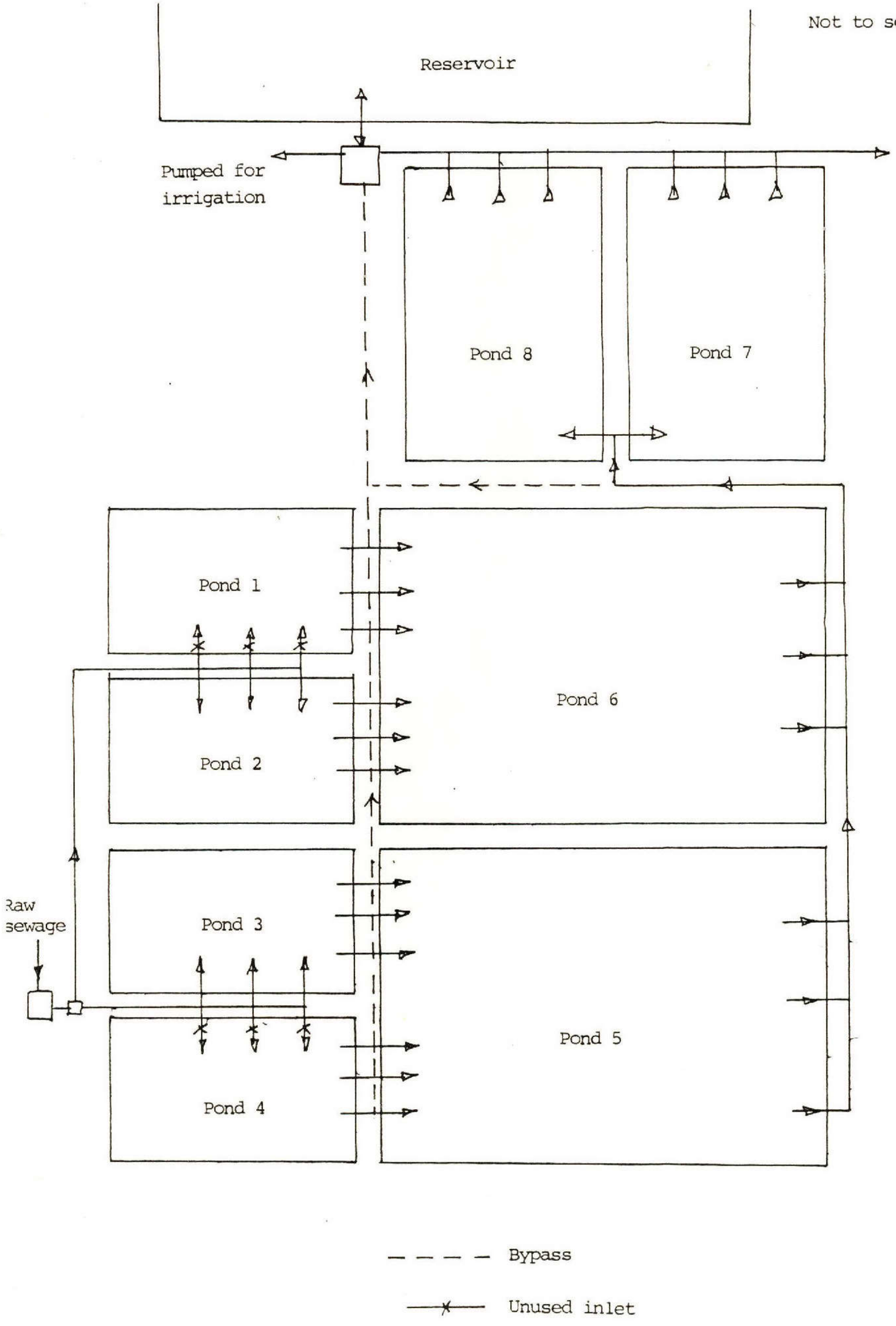
19.5 Problems and Recommendations.

The odour problem is being tackled by increasing the loading on the anaerobic ponds. This has resulted in some improvement. Further increases in loading rate by using one primary anaerobic unit and using the other three as parallel secondary units might result in further reductions in odour nuisance. The fly nuisance might well be reduced by more careful attention being paid to routine maintenance and the control of vegetation.

C105

BEER SHEVA - SCHEMATIC DIAGRAM

Not to scale



C2.20 ARAD, ISRAEL

May 26th

Client: Local Council
World Bank funded project 1975-76

20.1 Design.

a) There was no particular client resistance to the use of a pond system for wastewater treatment.

b) The design was based on empirical loading rates for anaerobic and facultative ponds, and the design assumptions are given below,

Design Parameter		Design Assumption (1985)	Actual
Population		20,000	12,500
Per capita wastewater contribution	l/c/d	165	130
Daily average wastewater flow	m^3/d	4,200	1,620
Per capita BOD_5 contribution	g/c/d	50	50
BOD_5	mg/l	303	385
BOD_5	Kg/d	1260	625

There is no contribution from industry.

The pond system is fed under gravity and comprises two parallel anaerobic and two parallel facultative ponds. The pond characteristics are given below,

Pond Characteristic		Ponds 1 & 2	Ponds 3 & 4
Volume	m^3	2 x 3,750	2 x 37,500
Depth	m	2.7	1.5
Freeboard	m	1.3	0.75
Liquid surface area	ha	2 x 0.15	2 x 2.5
Side slope		1:3.5	1:3.5
Detention time - design	days	1.79	17.9
- actual	days	2.3	23
BOD_5 Organic loading rate			
design - areal	Kg/ha/d	4,200	-
- volumetric	$Kg/m^3/d$	0.168	-
actual - areal	Kg/ha/d	4,170	-
- volumetric	$Kg/m^3/d$	0.166	-

* The design values are calculated using the full pond system. Since currently only ponds one and three are in operation the actual values for detention time and loading are based on just these two units in operation. The original design predicted a population of 13,000, flow rate of 2,150 m^3/d and BOD_5 load of 650 Kg/day for 1978.

c) The ponds are constructed on a Loess soil which has been used as compacted fill in the embankments. The ponds are not lined and there is no embankment protection at the water surface level.

There is no preliminary treatment and there is no flow measuring device. The pond outlets are at the surface and are provided with scum guards, the inlets are above the water surface. The ponds are not provided with a bypass or drain down facilities.

d) A 1.8m high 6 strand barbed wire fence surrounds the site.

e) There is no landscaping, but the pond embankments are vegetation covered. A dirt road is provided for access around the ponds.

f) There is no lighting.

g) There are no laboratory facilities.

h)

Gross area of site	13.6	ha.
Net area of ponds	5.4	ha.
Existing reserved land	30	ha.

The pond system is constructed on municipality owned land and is 3.5 km from the nearest housing and 2 km from the nearest main road.

i) There is no algal harvesting or fish farming.

j) The effluent is used for spray irrigation of cotton and corn by a kibbutz.

k) The estimated costs at time of bidding were not available.

20.2 Bidding.

No information was available on the list of bids received. Procurement and prequalification was carried out according to the standard requirements of the World Bank and the Israeli Sewage Project.

20.3 Construction.

Standard mechanical construction methodology was used, but no details of the equipment employed was available. Construction was completed in 1976, but with costs brought up to October 1980 levels, the investment was as follows,

Civil Works	US$ 290,000	88%
Engineering Services	US$ 40,000	12%
Total	US$ 330,000	

Assuming a final population served of 20,000 this represents an investment of US$ 16.5 per capita.

The additional costs incurred in construction of the ponds were covered by contingencies.

20.4 Operation.

a) No special start up procedures were used. There were no reports of nuisance in the early stages of operation.

b) The system is operated by the kibbutz who use the effluent for irrigation. There is no staff training and there are no organisation or maintenance manuals.

c) The operational costs of the system were not available but would appear to be minimal if the cost of pumping the effluent for irrigation is excluded.

d) There is no pond performance monitoring system, nor is there a regulatory standard for the effluent. The pond system is rather overgrown although there are no problems with exposed sludge or scum. Some odour is reported from the anaerobic pond during cold weather. Losses form the system are small and consist mainly of evaporation at 5mm/day. Due to the current flow being far less than the design flow, only one of each of the anaerobic and maturation ponds is being used. This leaves ample additional capacity should this be required to cope with increased flow, overloading or effluent change. The system has some flexibility in that any one of the ponds may be bypassed provided that the parallel unit is in operation.

e) The implementing agency seems satisfied with the operation of the pond system.

f) The effluent is successfully reused for spray irrigation of cotton and corn. When irrigation is not using the effluent it flows into a creek for disposal.

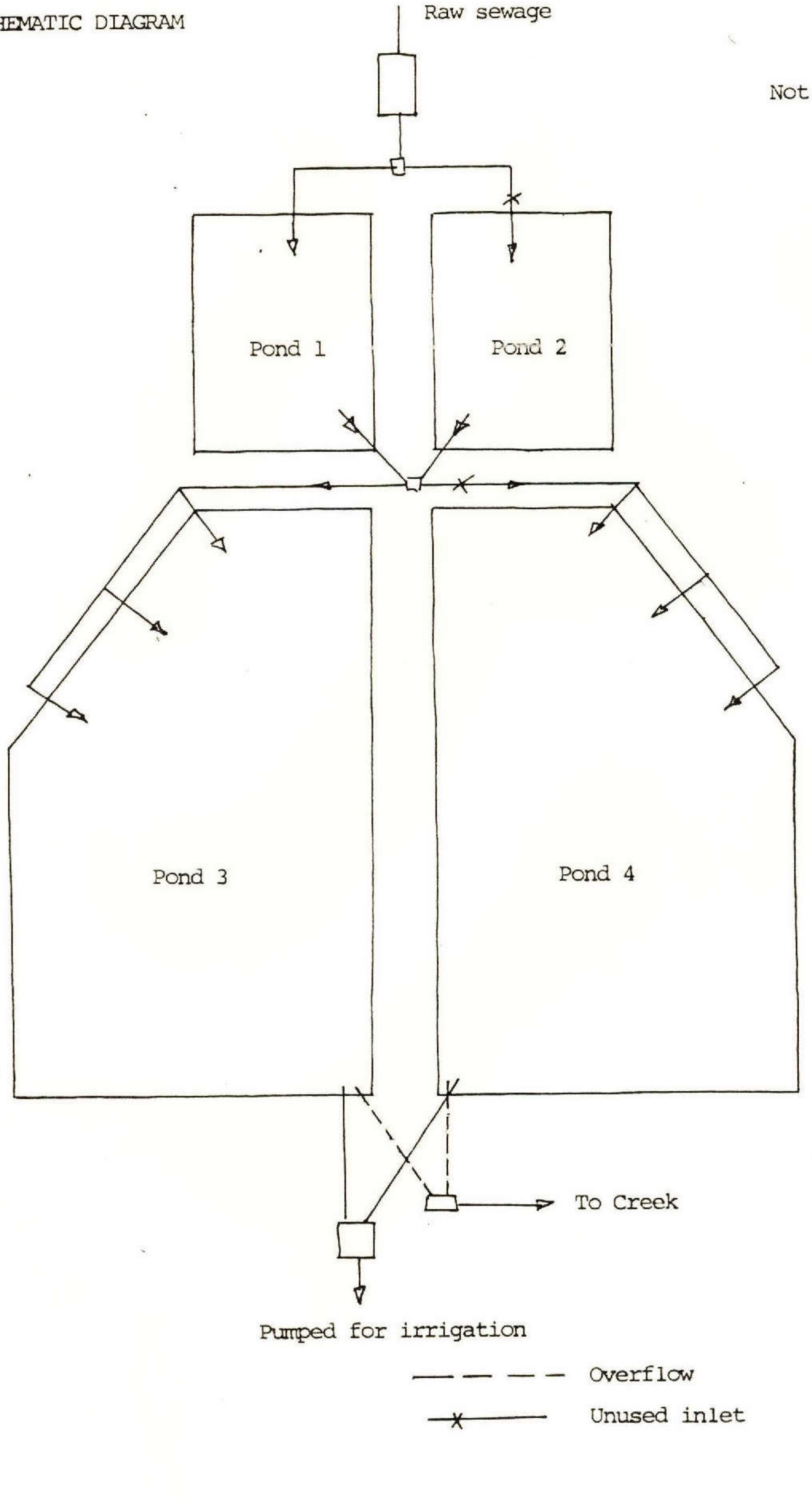
g) There is no chlorination of the effluent.

20.5 Problems and Recommendations.

The pond system is overgrown and requires more careful maintenance. The slight smell reported from the anaerobic pond during cold weather may be a feature of poorer treatment when the temperature is low. However, the anaerobic pond is slightly shallower than it ideally should be and this may also be responsible for causing some nuisance.

ARAD - SCHEMATIC DIAGRAM

Not to scale



C2.21 EILAT, ISRAEL

May 26th

Client: Town Council
No construction within World Bank project.

21.1 Design.

a) No client resistance to use of ponds for wastewater treatment initially.

b) The existing system is an emergency one designed to overcome odour problems. The original system comprised a system of waste stabilisation ponds including a high rate pond. This system was designed to serve a population of 34,000 by 1985, of which 20,000 were to be served by the high rate pond. The current population is 20,000 which swells to 30,000 in the holiday season. Information on the original design criteria is not available, but the actual existing values of design parameters are shown below,

Design Parameter		Actual value
Population		30,000
Per capita wastewater contribution	l/c/d	20
Wastewater flow	m^3/day	6,000
BOD_5 contribution	g/c/d	60
BOD_5	mg/l	300
BOD_5	Kg/day	1,800*

*There is approximately a 20% reduction in BOD_5 loading during pretreatment leaving about 1,440 Kg BOD_5/day to be treated in the pond system. The system now consists of two aerated lagoons which operate in series. The high rate pond is not operational. The pond characteristics are as follows,

Pond Characteristic		Pond 1	Pond 2	High rate
Volume	m^3	18,500	10,000	8,000
Depth	m	2.2	2.3	0.4
Freeboard	m	0.8	0.8	0.8
Liquid surface area	ha.	0.8	0.4	2
Side slope		1:3	1:3	Vertical
Detention time	days	3	1½	-
BOD_5 Organic loading				
- areal	Kg/ha/d	1,800	-	-
- volumetric	Kg/m^3/d	0.08	-	-
Aerators	hp	10 x 5	2 x 7.5	-
Power rating	watts/m^3	4	1.2	

The high rate pond was designed to have a velocity of flow of 0.3 to 0.4 m/sec.

There is no significant contribution to the raw sewage from industry.

c) The ponds are constructed on an area of silty clay which was used in embankment construction. The ponds are not lined and there is no embankment protection at the water surface level.

Preliminary treatment is provided by a rotostrainer to which some of the raw sewage is pumped and some fed by gravity. The rotostrainer has a 1.5mm mesh and removes about 20% of the BOD_5. There is no flow measuring device at the plant.

The pond inlets are above the surface and there are surface outlets which are provided with scum guards. There is a bypass for the ponds which allows the raw sewage to pass directly to a creek after it has been through the rotostrainer. There are no draw down facilities.

There are no major percolation losses, evaporation is about 5mm per day on average.

d) The plant is fenced with a 2m high chainlink fence with 3 strands of barbed wire at the top. This is mounted on tubular steel posts at 3.5m intervals.

e) There is no landscaping although parts of the site are very overgrown. There is good access to the site and down one side of the ponds on a gravel road.

f) There is no lighting except in the plant building. Additional security lighting is proposed.

g) There are no laboratory facilities.

h) Gross area of site 4.5 ha.
Net area of ponds 3.2 ha.
There is no existing reserved land.
The ponds are constructed on municipality owned land adjacent to a salt evaporation plant and 0.5 km from the nearest main road and the nearest housing.

i) There is no algal harvesting or fish farming. Some algal harvesting was planned for the high rate pond.

j) The effluent is reused for the irrigation of date plums by a neighboring kibbutz.

k) The estimated costs at time of bidding were not available.

21.2 Bidding.

The list of bids received was not available, nor was information on the procurement process.

21.3 Construction.

No information was available on the construction methodology used, although the ponds were constructed mechanically. Problems were encountered during the recent pond rehabilitation with regard to excavation and construction close to the high water table. The options considered were,

i) Pump out excavation
ii) Build high embankments and pump into ponds.

The former option was taken for the deepening of the two aerated lagoons.

The cost of the recent works to deepen ponds and provide rotostrainers and aerators was US$ 200,000. This represents a per capita investment of about US$10. There were no cost overruns in this work.

21.4 Operation.

a) No special start up procedures were used originally or after the recent rehabilitation. No particular odour problems were experienced in the early stages of operation.

b) The system is oeprated by the National water company Mekorot, who are hired by the municipality. There is one trained operator and two labourers. There are no organisational or maintenance manuals.

c) The cost to the municipality of operations being supervised by Mekorot is about US$ 40,000 per year. In addition to this there is the cost of power consumed by the aerators and rotostrainers.

d) There is no existing or planned pond monitoring system, neither is there a regulatory effluent standard. The pond system still has a slight odour in spite of the installation of the aerators, although the level of nuisance has reduced since the aerators were installed. The odour might also be due to the high rate pond which following eighteen months of operation is now covered with about 200m of sludge, and is being slowly emptied and dried. Also there is sitll some exposed sludge and scum in one of the aerated lagoons which was not removed during the recent cleaning operation.

There is some weed growth around the pond embankments and in the ponds.

Due to the heavy loading of the system there is currently no capacity to deal with overloading, increased flow or effluent change. Thus the flexibility of the system as it stands is very limited.

e) The implementing agency has been concerned by the odour problems which seem to have beset the treatment system, although these may have been resolved.

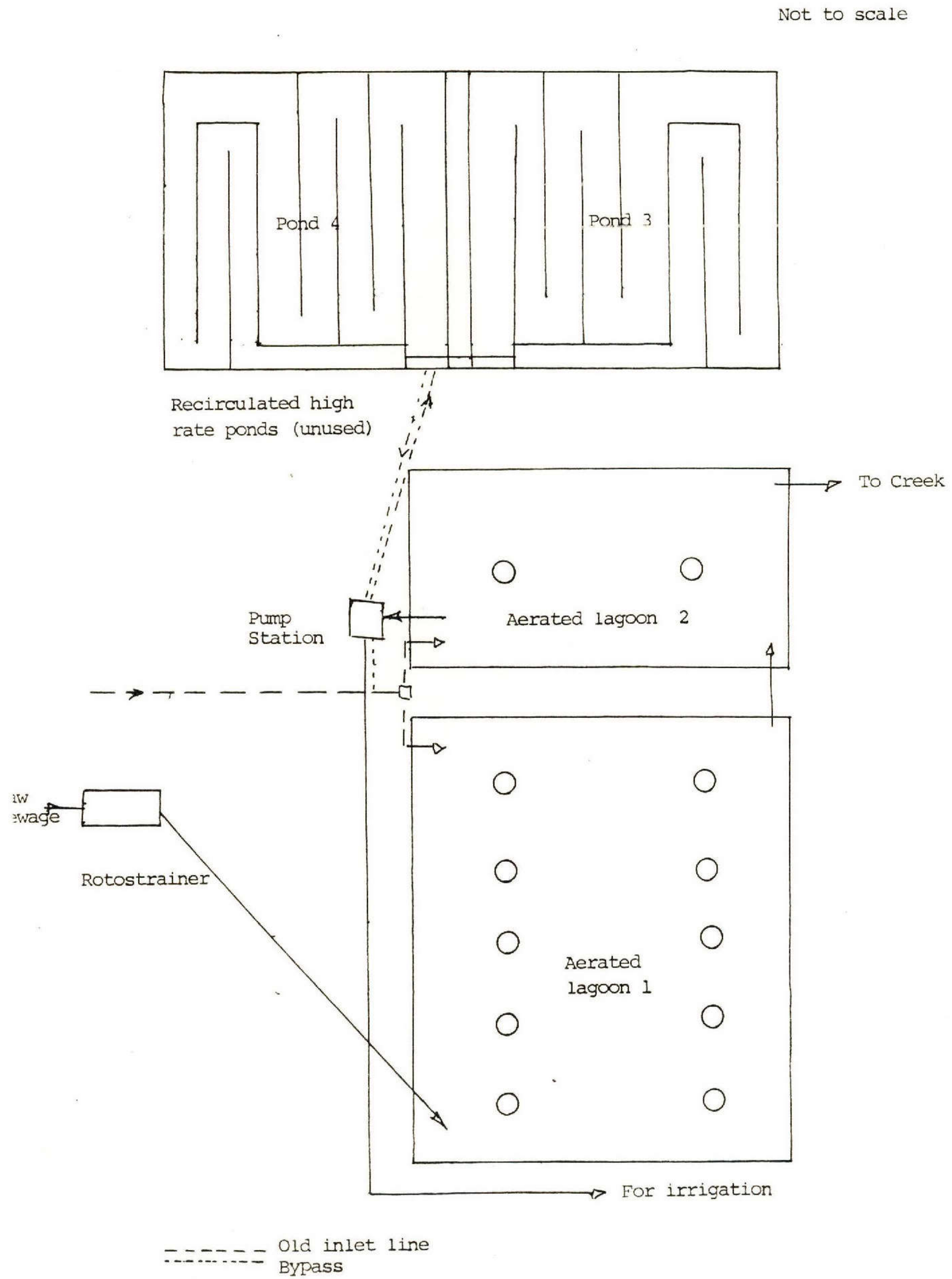
f) The effluent is generally reused for the drip irrigation of date palms by a kibbutz. When the effluent is not required for this purpose it is disposed of to an adjacent creek.

g) There is no chlorination of the effluent.

21.5 Problems and Recommendations.

For some reason the Eilat system has had a number of odour problems since its construction. Initially an anaerobic pond was constructed but after this caused odour nuisance it was demolished to leave the two facultative ponds to which the high rate pond was added. When this also suffered odour problems, the ponds were deepened, aerators were brought in, rotostrainers were used to reduce the BOD_5 loading and the high rate pond was taken out of service. This appears to have reduced the nuisance but some odour remains, possibly due to the exposed sludge in one of the lagoons or the empty high rate pond. Although the odour problem may be eliminated, there are likely to be further problems until improvements can be made to reduce the loading on the system.

EILAT - SCHEMATIC DIAGRAM



C3. KENYA

C3.1 DANDORA WASTE STABILISATION POND SYSTEM, NAIROBI.
June 1st-4th, 1981.

Client: Nairobi City Council - Bank Funded.

1.1 Design.

a) The client was happy with the use of ponds as a waste treatment system, particularly since a large area of land was available. They were also aware of other pond systems in Kenya having demonstrated their viability.

b) The design of the pond system was first considered in "First Stage Programme for Sewerage and Drainage" prepared by the consultants SWECO for W.H.O. and U.N.D.P. in August, 1974. This report pointed to the overloading of the existing Eastleigh and Kariobangi plants with a capacity of 48,000 m^3/day.

Estimated future wastewater flows at these plants were,

1975	64,000 m^3/day.
1979	97,000 m^3/day.

They proposed a first stage treatment plant to take 30,000 m^3/day. Potential sites were considered at varying distances from the city centre,

Site A	Close to city	- Insufficient area for future.
Site B	10km from city on river	- Insufficient area for W.S.P.'s
Site C	14 km from city on river	
Site D	16.3 km from city on river.	

The future wastewater flows from Nairobi, assuming a separate sewerage system, (apart from an area of 125 ha in the city centre, which has combined sewerage) were,

	1972	1975	1979	1985
Domestic m^3/day	35,100	44,800	60,600	131,700
Industrial m^3/day	4,800	7,200	12,800	24,300
Infiltration m^3/day	10,000	12,300	15,700	22,200
Total average flow m^3/day	50,000	64,000	97,000	178,000
Total population	360,000	460,000	670,000	1,080,000

Options considered were: Low rate trickling filters.
Activated sludge plant.
Waste Stabilisation ponds.

(NB: high rate trickling filters not considered because achieved effluent standard of 30-40 mg/l BOD_5 not considered high enough).

The wastewater treatment options considered were thus,

Option 1, Treatment in waste stabilisation ponds at Sites B, C and D.

Option 2, Treatment in waste stabilisation ponds at Site D only.

Option 3, Activated sludge process treatment at Site B.

Option 4, Extension to low rate trickling filters at existing Kariobangi sewage works.

The capital and operating costs were evaluated per m^3/day as follows (for 30,000 m^3/day capacity).

		Capital costs Kshs/m^3/day	Operation & Maintenance costs Kshs/m^3/day
1.	Low rate trickling filters	850	13.7
2.	Activated sludge plant	750	16.6
3.	Waste stabilisation ponds	400	7.0

These costs exclude the cost of land.

For reasons of cost as shown above, and for the reasons shown below, Option 2 was chosen.

i) Site B earmarked for development
ii) Good access to irrigation land.
iii) Least disturbance of existing communities.
iv) To the east of all areas planned for future development.

Cost estimates for the system were, (1974 prices)

Phase 1 (30,000m^3/day) 13 M. Kshs.
Phase 2 (additional 30,000m^3/day) 8.4 M.Kshs.

The city council accepted this proposal and obtained 2040 ha. of land by acquisition for a total price of 1.6 million shillings (ie 800 Kenyan shillings per hectare).

Design for the system was completed by VIAK consultants who assumed,

Percapita waste water contribution (for 1985)	high income	225 l/cap/day
	medincome	122 l/cap/day
	low..income	94 l/cap/day
Influent BOD_5		400 mg/l
Primary pond depth		1.75m
Primary pond BOD_5 loading rate		280 kg/ha/day
First order BOD_5 removal rate coefficient		0.27/day.

The design was based on the Marais rational design procedure. However although the primary pond is given a detention time of 25 days a further facultative pond of 10 days detention time is added, because of the following,

i) Commonly specified organic loading rate is 100 kg/ha/day.

ii) Higher bacterial removal with additional pond in the system.

iii) Improved BOD_5 removal with additional detention time.

Primary sedementation is recommended as an option to reduce BOD_5 loading on the pond system by 30%. This option was not accepted by the city council.

The system is designed for construction in 5 phases, each phase comprising construction of two additional identical pond systems in parallel, The proposed phases are as follows:-

	Inlet works	grit channel	additional capacity	total capacity
Phase 1	$5.4m^3/s$	$2.7m^3/s$		$30,000m^3/day$
Phase 2			$30,000m^3/day$	$60,000m^3/day$
Phase 3		$2.7m^3/s$	$30,000m^3/day$	$90,000m^3/day$
Phase 4			$30,000m^3/day$	$120,000m^3/day$
Phase 5			$30,000m^3/day$	$150,000m^3/day$

The pond system for each phase would comprise 2 no. of the following series in parallel.

Pond	Area	Depth	Volume	Detention Time.
1	21ha	1.75m	$367,500m^3$	25 days
2	8.6ha	1.75m	$150,500m^3$	10 days
3	8.8ha	1.2 m	$105,600m^3$	7 days
4	8.8ha	1.2 m	$105,600m^3$	7 days
Total	47.2ha		$729,000m^3$	49 days

Ave. daily flow $15,000m^3/day$
BOD_5 concentration 400 mg/l in influent

pond dimensions are:

Pond	Length	Bredth	Freeboard
1	710m	310m	1.5m
2	300m	310m	1.5m
3	300m	310m	1.5m
4	300m	310m	1.5m

A Brief for consultancy services in phase 2 has been proposed by Nairobi City Council. This calls for the design of additional ponds to increase plant capacity to $60,000m^3/day$, modifications to the inlet works and the provision of additional staff housing. It states that with only minor modifications, the 2nd phase system should have a general arrangement similar to that of the first phase.

No special attention has been given in design to provision for dealing with temperature variation and prolonged cold periods. In the case of Nairobi the temperature remains fairly constant throughout the year.

The ponds are designed to take up to 20% industrial effluent.

c) The soil conditions at the site are black clay(black cotton soil) on weathered rock (laterite). The black cotton soil was used in the embankments although a core comprising alternate layers of black cotton soil and local red clay was used in the centre of the embankment. This core was 2m wide and was compacted in maximum 200mm layers.

Percolation has not been found to be a problem although the balance of inflow and outflow from the ponds indicates a total loss from the surface area of 10mm/day of which an average 4.2mm/day is from evaporation and thus 5.8mm/day from percolation.

All the ponds were provided with embankment protection at the water surface level comprising cement flagstones extending 0.75m above and 0.5m below water surface level. Embankment slopes were 3 : 1 internal and 4 : 1 external.

The inlet to the primary ponds is above surface and comprises 2 no. concrete channels in each pond extending 200m into the pond with four outlets at regular intervals along their length. 2 no. interpond connections are provided for each pond with variable weirs and scumbords in a concrete pond outlet weir box. The inlets are submerged, and each pond has a bottom outlet discharging to a central drain for draw down.

A bypass is provided but this allows diversion of complete flow to Nairobi river only.

Flow measuring parshall flumes are provided at the inlet to the works and in the discharge channel to the Nairobi river.

Preliminary treatment comprises the following:-

i) Two stage screening - 1st stage 70mm spacing, 2nd stage 25mm spacing, automatically cleaned, plus a manually cleaned screen in the inlet works bypass channel.

ii) Two grit removal channels in parallel, with screw pump grit removers.

d) Fencing comprises concrete posts at 3.5m intervals with 5 strands of barbed wire and two spacing wires per bay. The height of the fence is about 1.5m. The buildings and preliminary treatment facilities are surrounded with 1.5m high chain link fencing plus 3 strands of barbed wire giving a total fence height of 1.8m.

e) Although there is no landscaping except near the office and inlet works, the external embankments are planted with grass to aid erosion control. The embankment crests are surfaced with murram (a granular material) and access to and around the ponds is good.

f) Lighting is provided with 4m high street lamps spaced at 20m intervals on the access road to the office and 100m intervals around the outside em bankments. 250 watt mercury lamps are used.

g) A room to be used as a laboratory is provided but no equipment or furniture has been obtained. Samples are collected regularly and these are occasionally tested at the City Council's main laboratory at the Kaiobangi treatment works.

h) Gross area of site currently fenced 140ha.
Net area of ponds 9 5ha.
Existing reserved land 1900ha.
The ponds are on what was a sisal estate and are 1.5km from the nearest main road and 500m from the nearest residential area which is the staff housing.

The site was selected for its distance from the city, proximity to the Nairobi river plus the other reasons mentioned above. It's position also enables nearly all the sewage from Nairobi to be fed to the ponds by gravity.

i) There are no ancillary uses, and no consideration has yet been given to fish farming.

j) The effluent is discharged directly to the Nairobi river and there is no effluent reuse. The land near the pond system is flat and appears to be ideal land for irrigation.

k) The only cost estimates with a breakdown available are those given in the 1975 design report. This gives,

General	800,000 kshs.
Inlet work	8,242,000 kshs.
Waste Stabilisation ponds	9,625,000 kshs.
Offices	1,224,000 kshs.
Staff housing	3,070,000 kshs.
TOTAL	22,927,000 kshs.
With 20% contingencies	27,060,000.kshs

1.2 Bidding.

Ten bids were received of which two were considered unsatisfactory.

The Mowlem Construction Co. Ltd.,	Kshs.	33,543,188
Victory Construction Co. Ltd.,	"	37,644,790*
Tarmac (E.A.)Ltd.,	"	39,027,004*
S.S.Mekta & Sons	"	39,535,976
G.Issaias & Co(K)Ltd.,	"	40,063,692
Llalji Bhinyi Sanghoni	"	41,390,000
Kunden Singh Construction (K) Ltd.,	"	45,550,112
Almed Khan Ltd	"	55,162,972
Tuigu Construction Co. Ltd	"	56,726,424
Baustrag Kenya Ltd	"	60,899,173

* Unsatisfactory bids.

There is no prequalification, but post qualification led to the rejection of two of the bids received. The rejections were due to the contractor being considered unable to satisfactorily carry out the works.

1.3 Construction.

Normal construction practices were employed using heavy earthmoving and compaction equipment. The contract was drawn up according to the International Conditions of Contract for Works of Civil Engineering Construction. Compaction of the embankments was carried out using vibrating sheepsfoot rollers to give 90% maximum density. Minimum compaction was specified as follows:-

Vibrating plate weight.	Overpasses	Max. layer thickness.
Minimum 400 kg.	4	0.2m
3 ton	6	0.3m
5 ton	6	0.4m

Hand compaction used near pipes and culverts.

Compaction tested every $500m^2$ of each layer.

No change orders required although the contractor was compensated for construction delay during heavy rain in 1978 when sitework was not possible.

Tender sum	Kshs	33,543,311
Actual final cost	"	33,598,500

1.4 Operation.

a) No special start up procedures were employed, no smell was experienced in early stages of operation.

b) Although no staff training was carried out, many of the senior staff at the Dandora ponds were previously employed at the now disuses Eastleigh Sewage Works. No organisation or maintenance manuals are used, but the staff appear to be competent and a high level of maintenance is maintained. Staff employed shown in Table 3.1

c) Operation and maintenance budgets for 1980 and 1981 (predicted) are shown below in kshs.

	Total	Debt Charges	Operation & Maintenance
1980	310,196	260,000	50,106
1981	317,106	275,000	42,106

Comparing the Kariobangi treatment works for the same years:

	Total	Debt Charges	Operation & Maintenance
1980	234,352	60,470 + 39,332	134,630
1981	182,026	62,889 + 36,774	72,363

d) Performance maintaining is undertaken by the chemist at the Kariobangi works. It is eventually planned to provide a fully equipped laboratory at the Dandora plant. The parameters recorded are as follows:-

pH
NO_2
NO_3
Ammonia as N_2
Ammonia Albuminoid
Chlorines
P.V. 4hrs. at 27°C
B.O.D.$_5$
C.O.D.
S.S.
and dissolved solids.

The average performance at the Dandora ponds from data collected in the past year is as follows:-

Parameter		Raw Sewage	Final Effluent.
pH		7.1	7.6
NO_2	mg/l	None	None
NO_3	mg/l	None	None
Ammonia N_2	mg/l	35.2	30
Ammonia Albuminiod	mg/l	9.6	8.8
Chlorines	mg/l	33	45
P.V.	mg/l	61	27.5
B.O.D.$_5$	mg/l	270	18
C.O.D.	mg/l	941	229
S.S.	mg/l	328	54
Dissolved solids	mg/l	384	554

TABLE C3.1.

DANDORA STAFFING LEVELS.

	Current staffing level	Proposed 2,000 staffing level.
Assistant Superintendant	1	1
Shift Engineers	2	2
Senior laboratory technicians	1	1
Junior Laboratory technicians	1	1
Sewer Foreman	5	9
Antisans	1	2
Drivers	2	4
Watchmen	6	10
Labourers	21	40
	40	76

Average flow rates for recent months are as follows:

	Inflow	Outflow
March 1981	48,600m^3/day	32,100m^3/day
April,1981	78,700m^3/day	71,200m^3/day
May,1981	68,100m^3/day	61,500m^3/day

Thus the design and actual loading rates on the primary ponds are as follows:-

	Design	Actual
$B.O.D._5$ loading rate	280 kg/ha/day	410 kg/ha/day
Average flow rate	30,000m^3/day	65,000m^3/day
Detention time (primary)	25 days	11.5 days
Detention time (complete system)	49 days	23 days.

The effluent standard required for discharge to the Nairobi river is the Royal Commission standard of 30 mg/l S.S. and 20 mg/l BOD_5. This is a most inappropriate standard since the Nairobi river at the point of discharge is improved by the sewage works effluent even at the 54 mg/l S.S. and 18 mg/l BOD_5 which is achieved.

There are no problems of smell, sludge build up or weed growth at the Dandora plant. There is a problem with the inlet works however which cannot cope with the large objects (e.g. dustbins) which appear in the sewer, or with the large quantities of grit in the obviously mixed sewage.

With the large pond areas good wind mixing is probably achieved although no laboratory work has been done on this. Wave action is not a problem because the hard edge detail prevents embankment erosion.

No scum was observed on the ponds and no mosquito larvae were present. There are complaints of mosquitoes in large numbers at night but these are more likely to come from the Nairobi river than the ponds. Problems are encountered with hippopotemi and crocodiles using the ponds although they appear to cause no damage, except to the boundary fence.

There are no special facilities for dealing with overloading, and coping with enhanced flow or effluent change. However, the fact that there are two systems in parallel makes the system reasonably flexible, though a lack of suitable interpond connections between the pond series limits this flexibility.

e) The implementing agency is very happy with the pond system and they are now looking for consultancy services and a loan to design and finance a phase two extension to the system.

f) The effluent is not formally reused and only a small amount is informally used downstream of the works where some irrigation with river water is carried out.

g) The effluent is not chlorinated and there would appear to be no reason why it should be ,since the river water at the effluent outfall is of inferior quality to the sewage effluent itself.

3.5 Problems.

The problems with operation of the Dandora waste treatment plant are restricted to the inlet works and the attraction the ponds posesses for hippopotomi and crocodiles.

3.6 Recommendations.

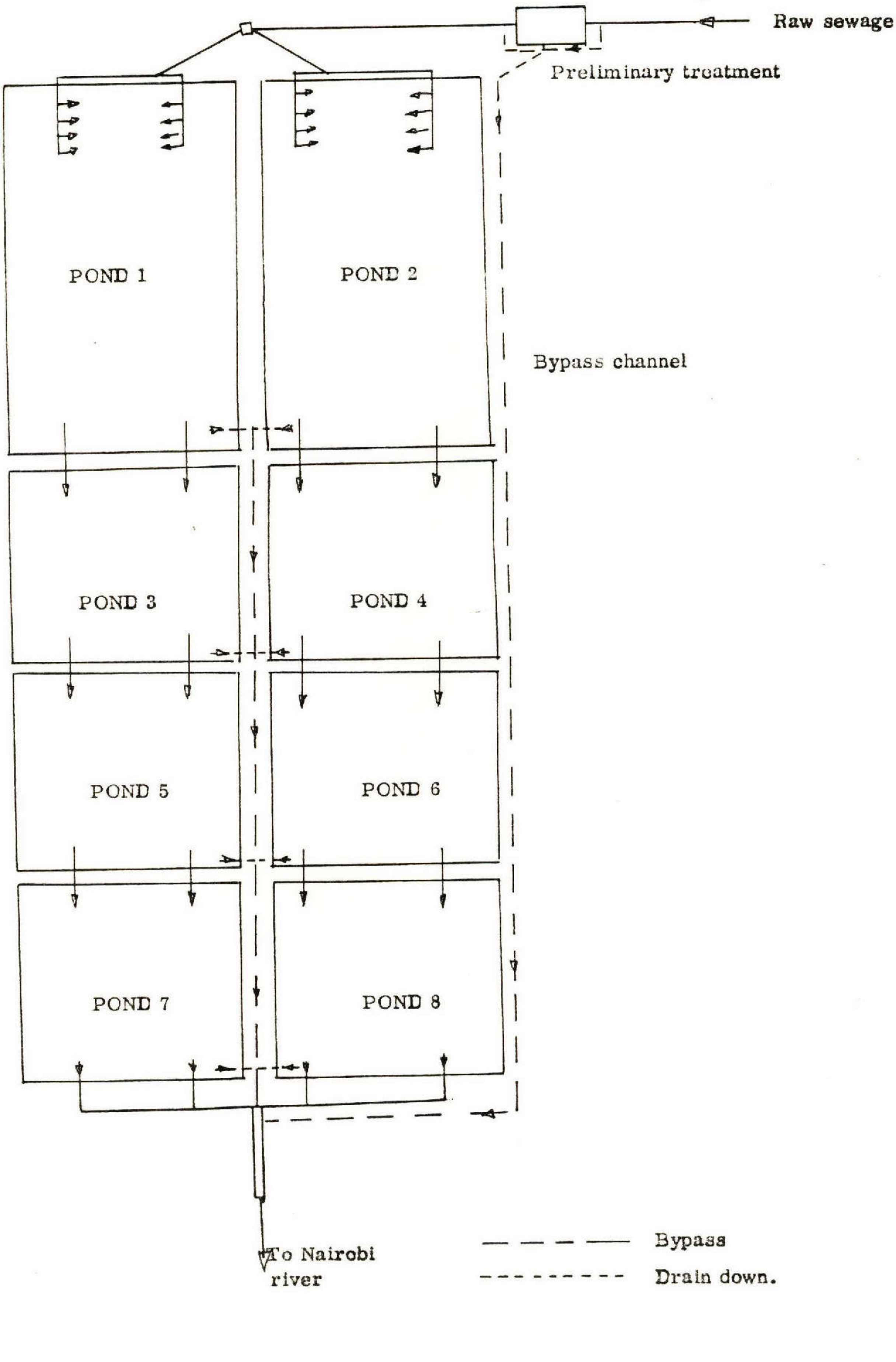
The pond system is functioning well in spite of the high hydraulic and organic loading rates. The phase two ponds should be constructed and the inlet works designed so as to take account of the problems being encountered due to large objects and large quantities of grit with the system currently in operation.

The problems experienced with wildlife in the ponds can only be solved by providing a sturdier fence. It is probably not worth the expense unless damage is being caused.

The laboratory analysis of influent and effluent quality should be performed on a more regular basis and should include bacteriological analysis.

DANDORA - SCHEMATIC DIAGRAM

Not to scale



C3.2 DANDORA (INDUSTRIAL ESTATE) WASTE STABILISATION POND SYSTEM

June 1st-4th, 1981.

Client: Nairobi City Council.

2.1 Design.

a) Client happy with pond system - no opposition.

b) Design of ponds outlined in 'First Stage Programme for Sewerage and Drainage' prepared by consultant s SWECO for W.H.O. and UNDP in August 1974. Design based on South Africa (Marais) procedure, making the following assumptions,

Parameter.

Influent BOD_5	350 mg/l
Detention time of Facultative ponds	17 days.
Facultative pond loading	250kg BOD_5/ha/day
First order BOD_5 removal rate coeff.	0.23
Design average daily flow	4,550m^3/d.

The system was designed with two primary facultative ponds in parallel each with a maturation pond in series with half the area of the facultative pond.

Pond Characteristics.

		Pond nos. 1 and 2.	Pond no. 3 and 4.
Volume	m^3	2 x 37,200	2 x 18,000
Depth	m	1.2	1.2
Freeboard	m	1	1
Liquid surface area	ha	2 x 3.2	2 x 1.55
Side slope		3 : 1	3 : 1
Design detention time	days	16.75	7.5
Design organic loading rate		250 kg/ha/day.	

No allowance was made for dealing with prolonged cold periods.

The pond system was designed specifically for industrial and trade effluent from East Nairobi Industrial Estate. The nature of the industries discharging to the ponds was not known but they appeared to be mainly light industrial and processing industries.

c) The ponds are constructed on black clay and this was used in construction of the embankments. No additional material was required for embankment construction since red friable clays were also found at the site and used with the black clay to provide an impermeable embankment core.

Wave protection of the embankments was provided by concrete paving slabs extending approximately 0.5m above and below the surface.

There are no apparent percolation problems.

Interpond connections are via. concrete channels with surface draw offs and screen guards. Inlets to the facultative pond are above surface with four inlets to each pond. Inlets to secondary ponds and submerged, and outlets surface weirs. All the ponds are provided with overflows and draw down facilities but the system has no bypass.

A venturi flume is provided at the inlet for flow measurement, but the flow measuring equipment is not working. No preliminary treatment is provided.

d) The fencing is 1.6m high 6 strand barbed wire on concrete posts at 3.5m intervals.

e) There is no landscaping although the outside embankments are grass covered. Good access is provided around all the ponds with a 'Murram' road surface, although this is currently overgrown with long grass.

f) There is no lighting at the plant.

g) No laboratory facility exists at the plant, laboratory analysis on samples periodically taken is carried out at the Kariobangi Sewage treatment works.

h) Net area of ponds 9.5ha.
Gross area of site 14 ha.
Existing reserved land 31.5ha.
Distance from nearest residential area is 3km and the distance from the nearest main road is 1km. The ponds are within the boundary of a large industrial area.

i) There is no ancillary use of the ponds.

j) There is no formal reuse of the effluent for irrigation. Although this is mainly industrial effluent, laboratory analysis does not suggest that effluent reuse for irrigation would cause particular problems. The surrounding land is flat and appears suitable for irrigation and some of the effluent is unofficially used for the irrigation of maize and vegetables by local farmers. The quality of effluent is not such that irrigation of vegetables should be permitted.

k) Itemised costs at the time of bidding were not available.

2.2 Bidding.

A list of bids received was not available although the procurement process will have been similar to that used for the Dandora ponds with post qualification of contractors.

2.3 Construction.

Constructional details are not available although the equipment employed is likely to have been similar earth moving and compaction equipment to that used for the Dandora ponds.

2.4 Operation.

a) No particular start up procedures were employed and no odours or other problems were encountered at start up. The initial hydraulic and organic loading rates were below the design rates, and consequently loading was increased slowly.

b) The pond system has no permanent maintenance staff and maintenance duties are carried out by staff from the Kariobangi treatment works. Labourers are supposed to be sent regularly to keep the grass cut and check on scum formation etc., but there appeared not to have been any maintenance carried out for some time. In spite of this the ponds were working well with no sign of scum build up, odour, or any other problems. There are no organisation and maintenance manuals relating to the pond system.

c) No information was available on operational costs since the operation and maintenance of these ponds is included in the budget of the Kariobangi works.

d) The pond performance has been monitored occasionally and averaged data for the past year of operation is shown below.

Parameter		Raw Sewage	Final Effluent.
pH		8.5	7.5
NO_2	mg/l	None	None
NO_3	mg/l	None	None
Ammonia(N_2)	mg/l	15.3	3.5
Ammonia(Albuminoid)	mg/l	24.9	5.6
Chloride	mg/l	71.6	46.7
P.V.(4hrs.@27^{o}C)	mg/l	103.4	29.9
BOD_5	mg/l	553.3	62.2
S.S.	mg/l	676.4	73.0
Dissolved Solids	mg/l	775.3	545.7

The regulatory standard is the Royal Commission 20mg/l BOD_5 and 30mg/l S.S. which as can be seen from the above data is not achieved here. However, the BOD_5 of the raw sewage is higher than predicted in design, and recent measurements have shown the flow rate to be 9,000 cum/day(compare the design figure of 4,500 cum/day).

Thus the BOD_5 loading rate on the primary ponds is,

		790 kg/ha/day
and the detention time	-primary	8.4 days
	-secondary	3.8 days.

In spite of this considerable overloading, the ponds do not appear to be causing odour nuisance, neither are there any signs of scum or sludge problems.

Weed growth in the ponds is avoided by the hard edge details.

Evaporation is 4.2mm/day, there are no particular problems.

No problem s are reported during cold weather although the temperature is fairly constant throughout the year.

The opportunities for coping with enhanced flow or effluent change are limited, although the parallel systems enable one pond to be removed from service whilst the others continue in operation. Similarly there are no special provisions for coping with cases of overloading.

e) The implementing agency is happy with the operation of the pond system.

f) There is no experience of effluent reuse.

g) Chlorination is not practical nor is it proposed.

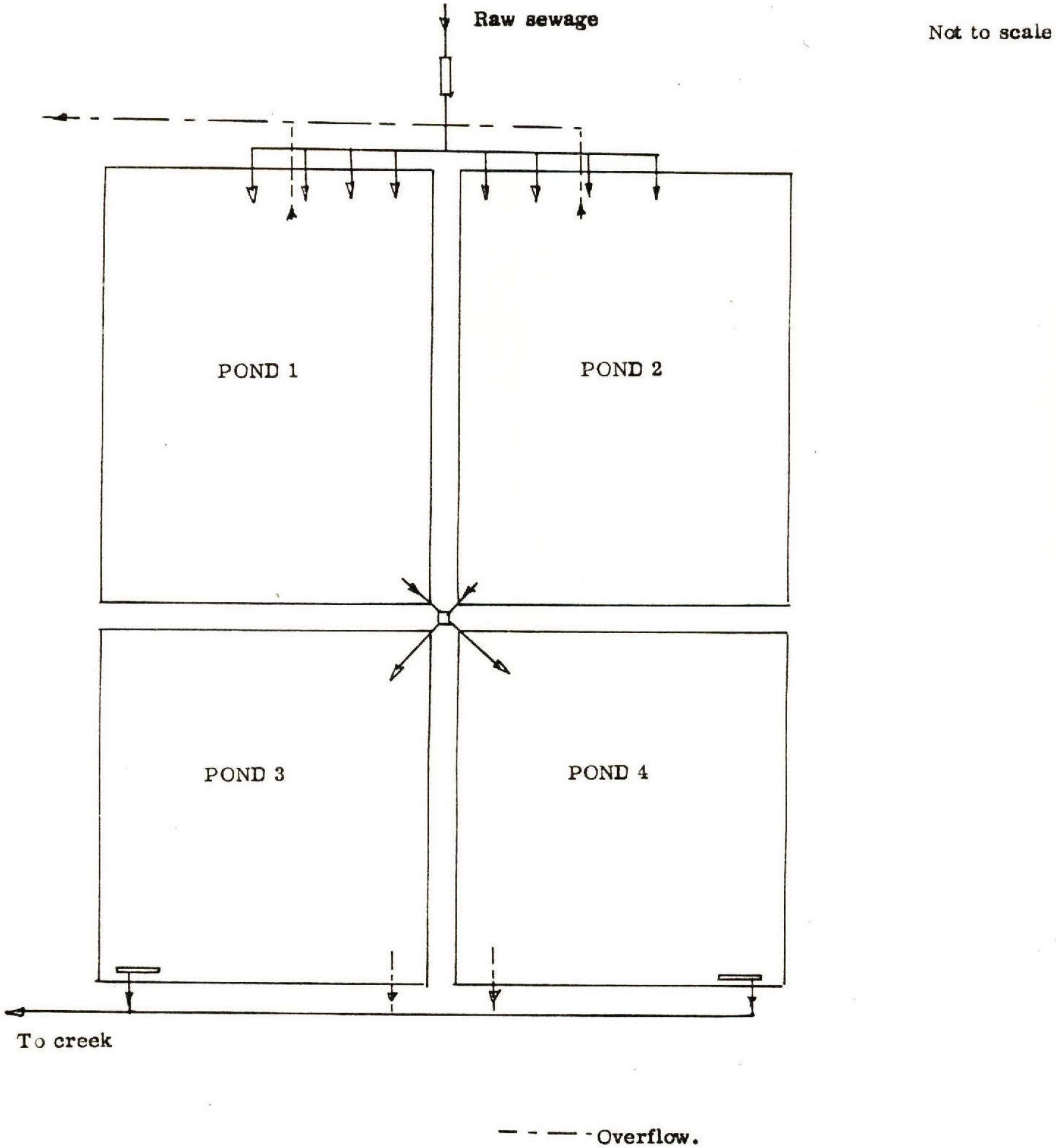
2.5 Problem Areas.

The pond system is working well and is a good example of a system treating almost exclusively industrial effluent. The system is overloaded and although it is functioning satisfactorily, maintenance is lacking.

2.6 Remedial Actions.

More attention should be paid to routine maintenance of the system. The flow measuring equipment should be repaired. The loading rates should be monitored and if, as the data available suggests, the loading rates are very high, the system should be extended. Analyses of bacterial removal should be undertaken and possibilities for effluent reuse reviewed.

DANDORA (INDUSTRIAL ESTATE) SCHEMATIC DIAGRAM.



- The pond system is designed with two primary facultative units in parallel and with secondary and tertiary units in parallel.

The design assumptions for the pond system are as follows,

TABLE C4.1.1 Design Assumptions.

Maximum flow rate	4,550m^3/day
BOD_5 of raw sewage	360 mg/l
"Accepted BOD_5 loading rate for Zambia"	112 kg/ha/day
Accepted BOD_5 of effluent	20 mg/l
Grit accumulation	7.2 ft^3/million gals.
Settling velocity of 0.2mm particles	54"/minute.

The grit channels are designed on the basis of an overflow rate of 0.075$m^3/S/m^2$, a peak flow of 105 litres/sec. and a channel velocity of 0.3 $msec^{-1}$.

The grit channels are each 8.15m in length.

The total pond area is based on the following equation:-

$$A = \frac{Q \times (L_o - L_e) \times 10}{\lambda \times 10^6}$$

where Q is the flow rate
λ is the areal BOD_5 loading rate
L_o is the influent BOD_5
L_e is the effluent BOD_5

This gives an area of 13.4ha using the design criteria given above. Thus the total pond area is based on the assumed areal BOD_5 removal rate.

The total area is divided into,

1st pond of 60% total area	8.27ha	(2 units)
2nd pond of 20% total area	2.77ha	
3rd pond of 20% total area	2.76ha	
	13.8ha	

Other pond characteristics are,

		Ponds 1 and 2	Pond 3	Pond 4
Volume	m^3	2 x 47,300	33,250	33,250
Depth	m	1.2	1.2	1.2
Freeboard	m	0.3	0.3	0.3
Design detention time		21 days	7.3 days	7.3 days
Slope (inside)		2 : 1	2 : 1	2 : 1
Design BOD_5 areal loading		205 kg/ha/day		
Outside slope		5 : 1	5 : 1	5 : 1

The tender documents produced in February 1976 also invited tenders for the electrical and mechanical equipment required for an activated sludge plant with the same capacity as the pond system. Those tendering for this system were also invited to give prices for the necessary civil engineering works for the activated sludge plant.

The pond system is not designed to cater for future increased flow although there is additional reserved land.

There are no special provisions for dealing with prolonged cold periods or temperature variation.

There is expected to be very little industrial effluent in the raw sewage received at the ponds.

c) The soil at the site is a dark brown sandy clay and is a lateritic soil. No additional material was required from off the site, for embankment construction and no lining was required. There is some evidence that compaction was not carried out as specified since a leak has developed in the embankment of Pond 1. The leakage is less than the total inflow to the ponds, which is itself very low, but is clearly visible on the outside of the embankment. There are serious problems with ants undermining the embankments at Ngwerere, and it may be that ants have caused the leakage problem observed.

There is a hard edge detail on all the ponds comprising precast concrete slabs of dimension 60 x 60 x 3cm,laid on a 1 : 3 cement mortar. Since the embankment slope is 1 : 2 this protection extends only 15 cm. vertically above and below the water level.

Apart from the leak mentioned above,further leakage is taking place from incorrectly seated penstocks used for draining down the ponds. The ponds are not yet full and this may be due to percolation problems although they have only been in operation for two months. A more likely reason for them taking so long to fill is the very low sewage flow.

Ponds 1 and 2 are served by multiple above surface inlets provided in a concrete channel which runs out into the ponds above the water surface. Interpond connections comprise surface draw off with metal grid and single submerged inlets.

There is a venturi flume provided at the inlet for flow measurement but the meter has either not yet been installed or has been stolen.

Bypasses are provided for all of the ponds, and they are also all provided with facilities for draw down.

Preliminary treatment comprises a manually cleaned bar screen and dual grit channels.

d) The fencing provided is 1.5m high 4 strand barbed wire fencing on tubular steel posts at 4m intervals. Some of this fence and parts of the gates have been stolen.

e) Although there is no landscaping, the outsides and tops of the embankments have been planted with grass to prevent erosion. Road access is provided around all the ponds, although no granular surface is provided.

f) Lighting is not provided except in the office building. Parts of the circuitory and the lights have been stolen from the office building.

g) There is no laboratory building.

h) Gross area of treatment site 20ha.
Net area of ponds 13.8ha
Reserved land approx 157ha.
The site is on an area of land some distance to the North of the city, a large area of which has been purchased by the city. The land was formerly used for grazing and the ponds are approximately 500 metres from the nearest village and 10km from the nearest main road.

i) Neither harvesting of algae or fish farming have been considered so far.

j) Although there would appear to be possibilities for effluent reuse for irrigation since the land is flat and lacks water, there are no proposals for effluent reuse.

k) Estimated costs at time of bidding are given below,

Preliminary and general works	Kwacha	73,590.00
Clearing, grubbing and topsoil stripping	"	19,945.00
Embankment construction	"	32,430.00
Excavation	"	53,702.40
Inlets, outlets and bypass pipe	"	2,109.00
Concrete and blockwork	"	44,744.00
Preliminary treatment etc.,	"	6,205.00
Fencing and gates	"	10,157.00
Total including 5% Contingencies	Kwacha	219,652.02

1.2 Bidding.

Bids received for the construction of the waste stabilisation pond system were as follows:-

A.E.Denovan	Kwacha	291,052.02
Town Construction Co.	"	305,305.00
Kerbot Construction	"	362,470.50
Titon Builders	"	401,493.23
Construction Engineers and Builders	"	412,348.12
Micron Transport	"	423,081.75
Allied Contractors	"	478,615.70
Burton Construction	"	532,408.72
Delkins Ltd.,	"	558,555.38
Mistry Velji Sarji & Co.	"	607,986.75

Tenderers are prequalified according to experience, equipment etc. and in this case the lowest tender was accepted.

The pond system was originally tendered with the trunk sewer in 1975 but since all the bids were high (about double the estimate) the trunk sewer and pond system were split and separate tender documents prepared for each. All the contractors tendering were prequalified.

1.3 Construction.

The normal range of earth moving and compaction equipment was used. Compaction of embankments was specified at 95% maximum density by modified AASHO standard. Testing of compaction achieved was carried out for every $500m^2$ of each layer, after final compaction CBR $> 10\%$ required.

Construction commenced August 1976 and was completed in November, 1977.

The appraisal report provision was	Kwacha	294,800
The consultants estimate was	"	362,000
The final sum was	"	312,604

This was an increase of K 35,000 or 12.6% over the tender sum and was due to the following increases:-

i)	Increased cost of materials	K 9,000	25.7%
ii)	Increased cost of labour	K 8,000	22.9%
iii)	Increase due to extra works	K18,000	51.4%

The contractors performance was stated as highly satisfactory. The cost per capita served is US$15.

1.4 Operation.

a) There were no special start-up procedures employed during the early stages of operation of the ponds - which is now. No odour problems have been encountered, and in view of the weak sewage and low flow rate at present, special start up procedures are unnecessary.

b) No staff training has been carried out, and the staff at the moment comprise one labourer/foreman and two labourers. There are no organisation or maintenance manuals.

c) Operational costs at the plant are minimal at the moment, since only three labourers are working there, and no equipment or chemicals are being used. There are plans to have 8 to 10 workers based at Ngwerere but funds must be found for this. Exlcuding wages which are approximately K80 per man per month the total maintenance budget for all the sewage treatment systems in Lusaka for 1981 is K 8,000.

d) There is no planned or existing system for regular monitoring of the treatment efficiency and effluent quality from the ponds. Regular monitoring of the other wastewater treatment systems in Lusaka is carried out, and the Ngwerere ponds should be added once they become fully operational. The parameters regularly monitored at the other treatment plants are,

B.O.D.$_5$
C.O.D.
P.V.
S.S.
T.D.S.
pH
Phosphates
Nitrates
and Ammonia.

To these should be added some form of faecal bacterial indicator organism, preferably faecal coliforms, if the necessary laboratory equipment can be obtained.

The effluent standard required is the Royal Commission 30 mg/l S.S. and 20 mg/l B.O.D.$_5$ standard. No effluent has yet flowed from the pond system, but with the high algal concentration one would expect from these ponds this standard is unlikely to be achieved.

There has been insufficient time for any smell or sludge problems to occur but there is weed growth both on the embankments and in the ponds themselves. Possible reasons for this and the solutions are given below.

Daily evaporation averages about 6mm, and in the ponds filled so far there appear to be no problems associated with wind and wave action or scum formation.

There are no special facilities for coping with enhanced flow or effluent change or for dealing with isolated cases of overload. There is a certain amount of flexibility built into the system but only in terms of the bypassing of units.

e) The impelmenting agency is happy with the pond system although they have had serious problems with the construction of the trunk sewer to the works which is why 3 years elapsed between construction of the ponds and their commissioning.

f) There is no effluent reuse experience in Lusaka except that of farmers taking river water or sewage effluent on an unofficial basis.

g) There are no plans for chlorination of the effluent.

1.5 <u>Status and Problems.</u>

Due to contractual problems with the trunk sewer to the pond system, it was not completed until the end of last year, and consequently the ponds lay idle for 3 years after completion, of which only one year was covered by the contractor's maintenance period. As a result the system had fallen into disrepair by the time the trunk sewer was completed and the Housing Project Unit have paid 30,000 Kwacha to the City Council over the past year to pay for the rehabilitation of the pond system.

This pond system is now being maintained by the City Council although only 3 of the proposed 10 staff have so far been allocated to the plant. There are still a large number of maintenance problems including,

i) Growth of grass from the main body of the ponds even in those which are now full. The operators say that this grass has grown since the ponds were filled.

ii) Ants are causing major problems in the embankments, where holes of more than 1 meter deep and about 100mm in diameter have been caused.

iii) The facility is frequently 'raided' for building materials and anything else of use. Since recent replacement of many of the facilities following the two year period without supervision, the following items have again been stolen.

- water pump
- window frames from office building
- doors from office building
- part of roof from office building
- parts of the fencing, gates and gate posts
- attempts have also been made to remove parts of penstocks and any moveable parts of the pretreatment system.
- all the facilities in the office building have been removed or broken.

iv) The maintenance staff do appear to be concienciois, but are not prepared to stay overnight because there are no facilities and no lighting (all the fittings and fixtures have been stolen).

4.6 Remedial Actions.

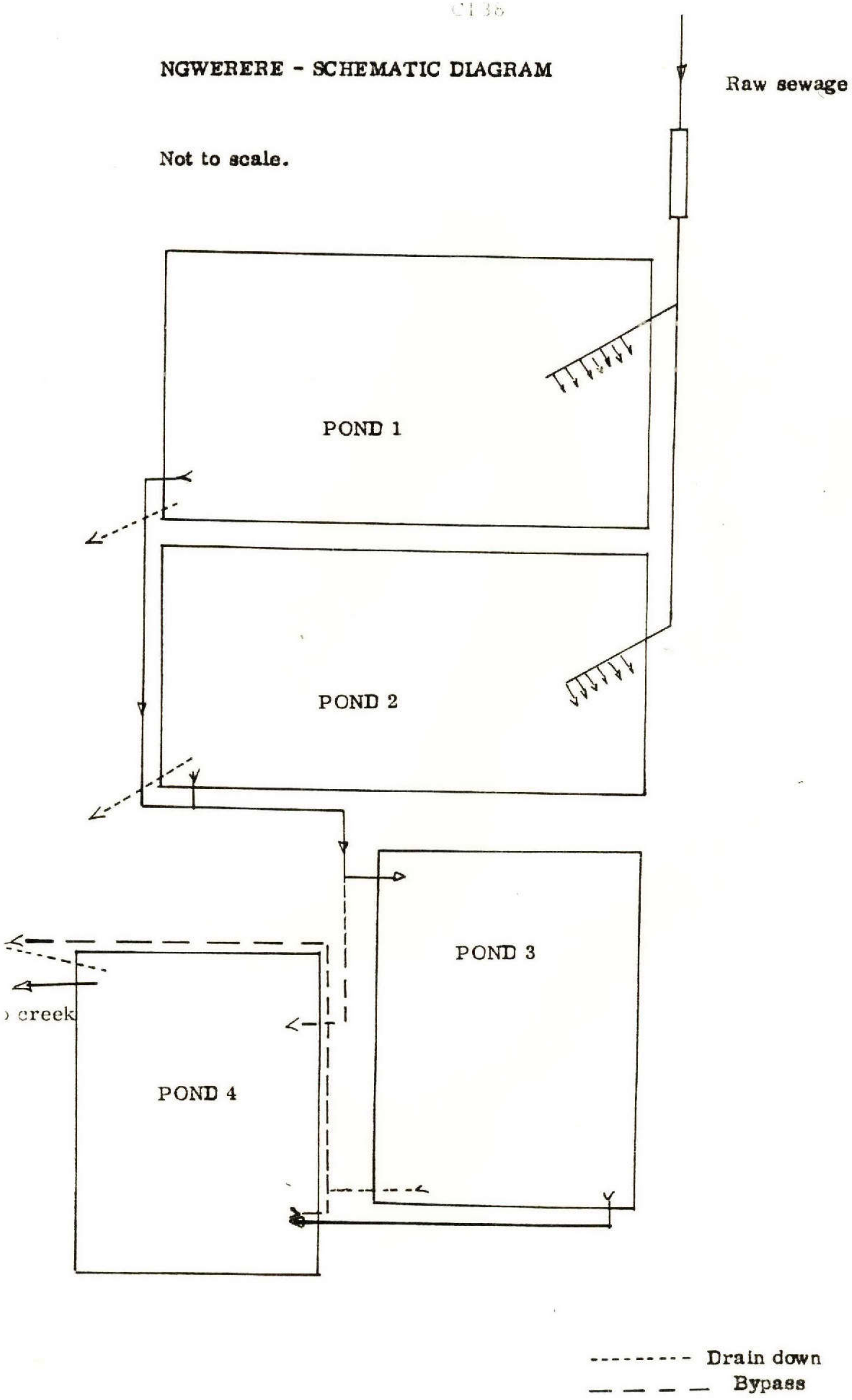
a) The grass should be removed from the ponds using a boat. The reason for the grass growth is probably the very weak sewage and quite shallow ponds. This growth should stop once the loading is heavy enough to prevent sunlight from reaching the bottom of the ponds.

b) Additional maintenance staff should be provided for the Ngwerere ponds and the damage will have to be made good. This should not be done untill the staff have been employed to look after the site.

c) A major decision should be made on the maintenance philosophy to be adopted. Either i) considerable presence must be maintained at the ponds day and night to prevent burglary of equipment and damage to facilities or ii) All removeable or damageable equipment should be placed underground and maintenance duties be carried out only during the day.

NGWERERE - SCHEMATIC DIAGRAM

Not to scale.



C4.2 MANCHICHI, LUSAKA.

June 5th

Client ; Lusaka City Council.

2.1 Design.

a) No resistance to use of ponds.

b) The pond system comprises 8 maturation lagoons in two streams of four. The first pond in each stream behaves as a facultative pond, and the system treats effluent from an overloaded biological filtration plant. Design was carried out on an empirical basis and the physical characteristics of the pond system are as follows:-

		Ponds 1 and 2	Ponds 3,4,5,6, 7,8.
Area of each pond	ha	4.2ha	2.4ha
Volume " " "	m^3	75600	36000
Depth	m	1.8	1.5
Freeboard	m	0.6	0.6
Slope		1 : 2 . 5	1 : 2 . 5
Detention time of each pond	days	5	2.5
Approximate BOD_5 loading rate	kg/ha/day	240	

The flow rate through each stream of ponds is about 15,000m^3/day.

The ponds are basically a tertiary treatment process but also perform well as a buffer against poor effluent quality from the conventional treatment works which may have a BOD_5 as high as 200 mg/l in the effluent.

c) The soil at the pond site is a lateritic soil which was used for the embankments. No soil was required from off the site.

There is some sign that settlement of embankments has occured, although there have been no leakage problems. The evidence of settlement is that in places the hard edge detail of rip rap originally at the water surface is now below the surface and erosion of the embankments is being caused. Since the freeboard at these points appears unchanged it may be that the wave protection strip has slipped down the rather steep embankments (1 : 2 . 5).

Submerged inlets are provided to all the ponds and outlet weirs without scum guards are used.

No flow measuring device is provided for the ponds although the inflow to the main treatment works is monitored.

No bypass is provided for the pond system although each pond does have facilities for complete draw down.

d) A 2m high chain link fence is provided for the ponds but this is in poor repair, vegetation covered and breached in many placed.

e) Road access to the ponds is reasonable but access around the ponds is poor due to the rather narrow embankments. The embankments are planted with grass which is kept short, and part of the land around the ponds is used for farming on a small scale.

f) There is no lighting.

g) A fully equiped laboratory is provided at the adjacent main treatment works with the equipment necessary to perform the basic chemical and biological analyses of samples.

h) Gross area of pond system is 37ha
The net area of the ponds is 23ha
The site is located within a residential area only 20m from the nearest housing and 500m from the nearest main road. There is no reserved land and the whole treatment system appears ripe for levelling and reuse for housing.

i) The harvesting of algae through fish farming has been considered and the ponds are full of fish which are occasionally caught and eaten or sold by the local people. Due to the lack of proper organisation, the ponds now appear to be over stocked and no very large fish were observed in the ponds. The City Biochemist (Mr. Mensa) has been pushing to try and get the City Council to run a pilot fish farming project.

j) The effluent is discharged to a neighbouring creek and only small amounts of effluent are reused informally by people irrigating vegetable or maize patches.

k) The costs at time of bidding were not available.

2.2 Bidding.

The list of bids received was not available. The contractors bidding for the construction of the ponds were prequalified by the City Council and the lowest bid was accepted.

2.3 Construction.

No information was available on the construction of the ponds or on the total actual costs incurred.

2.4 Operation.

a) No special start up procedures appear to have been used, there were no reports of smell in the early stages of operation.

b) There are 10 labourers assigned to the pond system who are all engaged in basic maintenance duties. They are supervised through the foreman working at the main treatment plant. There are no organisation and maintenance manuals and there is no special staff training for pond system maintenance.

c) Operational costs for the pond system are estimated at 10,000 Kwacha per year. The chemicals and equipment used are minimal.

d) The pond performance is monitored in terms of the major chemical and biological criteria, and the mean values for some recent analyses are shown below:-

		Influent	Effluent.
pH		7.6	9.6
Phosphate	mg/l	6.9*	2.7
Nitrate	mg/l	3.2*	0.9
Ammonia	mg/l	16.2*	0.9
BOD_5	mg/l	120	40

* these values are for the raw sewage influent to the main treatment plant.

One recent analysis of the nos. of E.Coli in the effluent gave 2,100 E.Coli per 100ml.

The effluent standard required is the Royal Commission 30 mg/l S.S. and 20 mg/l BOD_5 which is very seldom attained by the ponds due to the high algal concentration in the final effluent.

No problems are reported with smell, weed growth or poor performance in cold weather, sludge build up is low because the ponds follow a conventional treatment plant.

The only wave action problems occur where the water level is above the edge protection.

There are no special facilities for coping with enhanced flow, cases of overload or effluent change. The pond system is not particularly flexible.

e) The implementing agency is very happy with the pond system.

f) There is no experience of effluent reuse.

g) Chlorination of the final effluent is not provided.

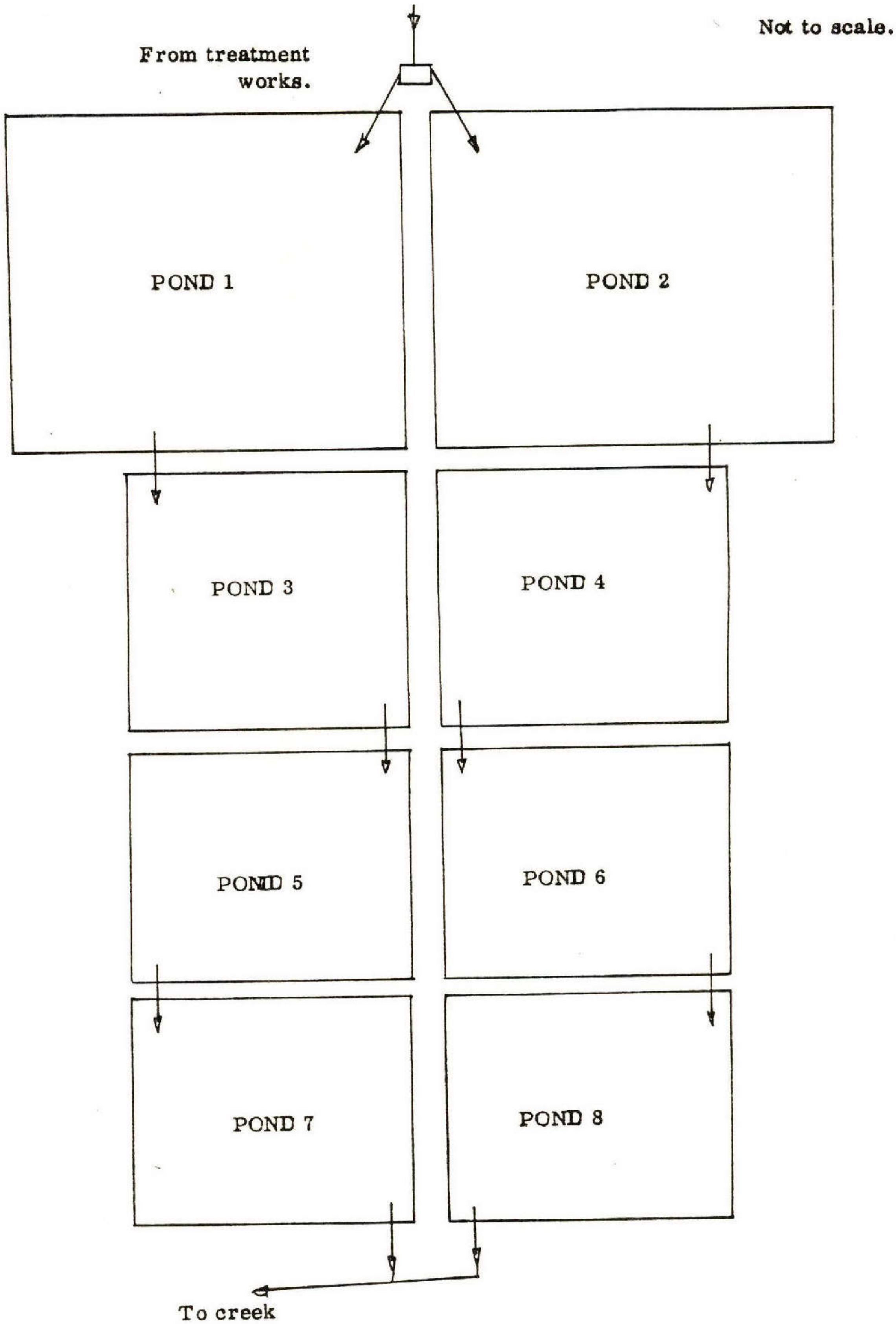
2.5 Problems and Recommendations.

There are no problems in the operation of the pond system. Where the embankment protection has sunk below the water surface some embankment repair is required.

The pond system would appear to be a potential source of revenue for the City Council. Ponds 3 to 8 could be used for a fish farming pilot study and the effluent could be reused for irrigation. Mr. Mensa, the city Biochemist has already suggested to the City Council that a fish farming scheme should be implemented.

C143

MANCHICHI - SCHEMATIC DIAGRAM



C4.3 MATERO, LUSAKA

June 5th.

Client: Lusaka City Council.

3.1 Design.

a) No resistance to use of ponds.

b) The Matero ponds comprise 3 separate pond systems each of 3 units and each running in parallel. The design for all the systems was on an empirical basis, each treats raw sewage which flows to the systems down one sewer and is split randomly between the three.

Pond characteristics for series 1 are,

		Pond 1	Pond 2	Pond 3
Area	ha	1.2	0.6	0.4
Volume	m^3	18,000	9,000	6,000
Depth	m	1.5	1.5	1.5
Freeboard	m	0.5	0.5	0.5
Slopes		1 : 3	1 : 3	1 : 3
Approximate detention time		12 days	6 days	4 days
Approximate BOD_5 loading		320 kg BOD_5/ha/day		

Pond characteristics for series 2 are,

		Pond 4	Pond 5	Pond 6
Area	ha	1.2	0.3	0.3
Volume	m^3	18,000	5,400	5,400
Depth	m	1.5	1.8	1.8
Freeboard	m	1.0	1.0	1.0
Slopes		1 : 3	1 : 3	1 :3
Approximate detention time		12 days	4 days	4 days
Approximate BOD_5 loading		320 kg/BOD_5/ha/day.		

Pond characteristics for series 3 are,

		Pond 7	Pond 8	Pond 9
Area	ha	3.75	1.4	1.4
Volume	m^3	56,000	21,000	21,000
Depth	m	1.5	1.5	1.5
Freeboard	m	0.6	0.6	0.6
Slopes		1 : 3	1 : 3	1 : 3
Approximate detention time		25 days	9 days	9 days
Approximate BOD_5 loading		154 kg/BOD_5/ha/day.		

Each pond series has been constructed as the previously existing units have become overloaded. Further land appears to be available around the ponds for further extensions.

There are no special facilities for dealing with temperature variation, overloading or effluent change. The flexibility of the pond system is limited since there is no interconnection between the three separate systems. The raw sewage is purely domestic.

c) The ponds are constructed on lateritic soil which was used in construction of the embankments. The ponds are not lined, nor is there any embankment protection at the water level. Wave action is causing some embankment erosion particularly on the larger ponds.

The ponds all have surface outlets without scum guards, and submerged inlets. Preliminary treatment is provided for each facility by bar screen, and venturi flumes are provided for flow measurement although none of them are working.

The primary units are provided with a bypass, but draw down facilities are not provided for any of the ponds.

d) There is no fencing.

e) The embankments are all planted with grass which is kept short, access to the ponds is good, but around the ponds is difficult.

f) There is no lighting.

g) There is no laboratory.

h) Gross area of sites: 15 ha.
Net area of ponds 10.55 ha.
The land is close to residential areas (500m) and about 1 km from the nearest main road. Although there is no land reserved, most of the land surrounding the ponds appears to be unused and would be suitable for further extensions.

i) There are no ancillary uses although fish are present in the ponds.

j) There is no official reuse of the effluent for irrigation.

k) The costs at bidding are not available.

3.2 Bidding.

A list of bids was not available. Each of the three systems was constructed at a different time.

3.3 Construction.

No information is available on the construction methodology, range of equipment employed or the total actual costs of the pond systems.

3.4 Operation.

a) There is no information on any start up procedures or smell in early stages of operation.

b) There are 8 staff assigned to the Matero pond systems. They are all labourers and are not trained. There are no organisation or maintenance manuals.

c) Operation costs are about 8,000 Kwacha a year of which nearly all is for wages.

d) Pond monitoring is carried out by the laboratory staff based at the Manchichi Sewage works. The major chemical and biological criteria are monitored, although on a very irregular basis. When averaged out,the effluent quality achieved from each of the pond systems is,

BOD_5	35 mg/l
S.S.	55 mg/l
E.Coli.	2,500/100ml

The effluent standard required is the Royal Commission standard of 30 mg/l S.S. and 20 mg/l BOD_5.

There are no problems with sludge build up, weed growth or pond performance during cold weather. The first pond in the earliest of the systems was emptied and desludged after 10 years of operation without problems.

Some algal scum was observed on the ponds but only occupying very small proportion of the surface. Weed growth was occuring at the water surface level due to the unprotected embankments, although the regular maintenance was keeping weed growth down.

e) The City Council has not experienced major problems in the operation of the pond systems.

f) There is no official reuse of the effluent, although some is used on a very small scale.

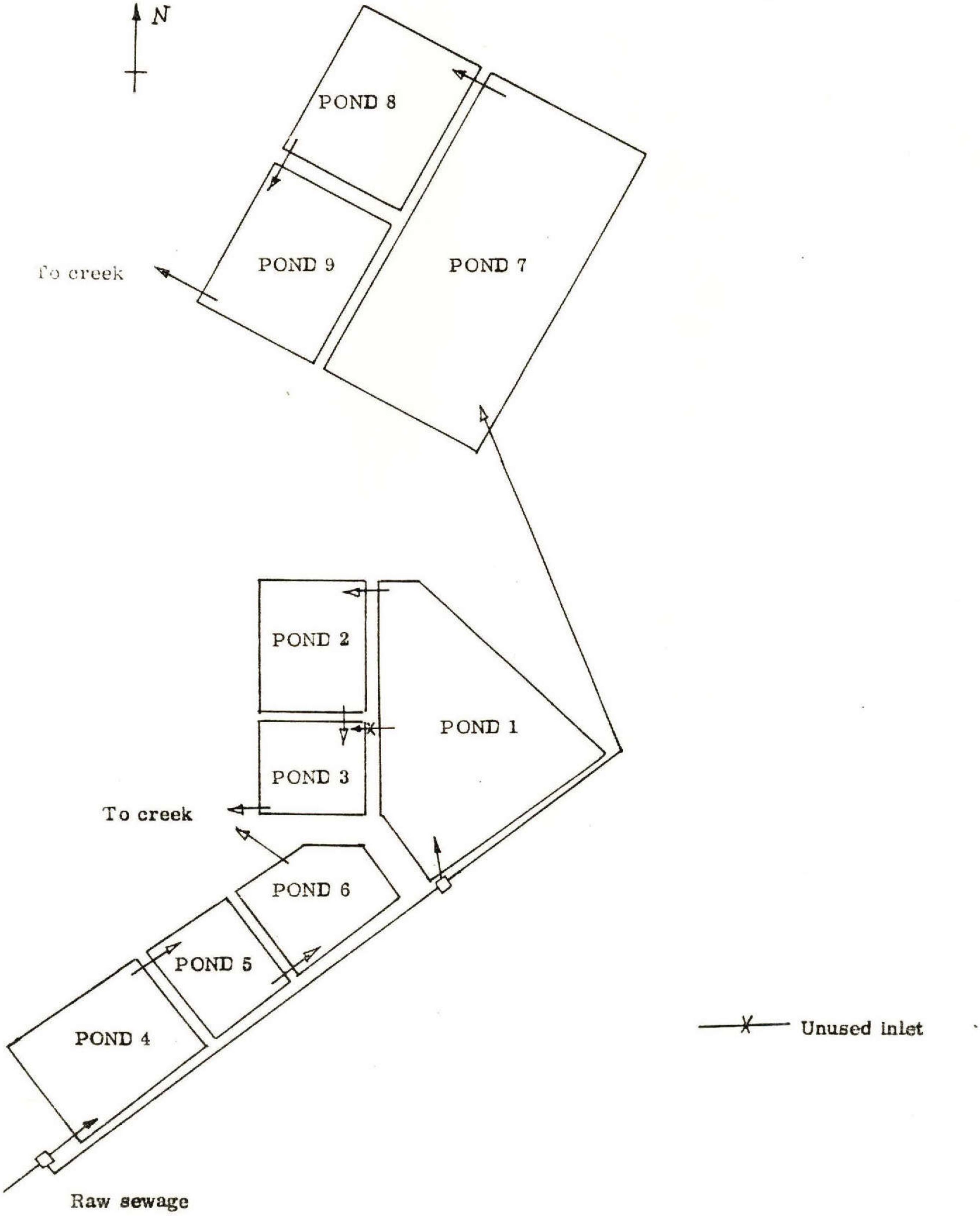
g) Chlorination is not provided.

3.5 Problems.

There appear to be no problems associated with these pond systems, except that the unprotected embankments mean difficulty in controlling vegetation at the waters edge.

MATERO - SCHEMATIC DIAGRAM

Not to scale.



C4.4 CHELSTON, LUSAKA.

June 6th.

Client: Lusaka City Council.

4.1 Design.

a) No resistance to the use of ponds.

b) The Chelston ponds comprise 3 series units, and the system was designed by Marais - presumably using the rational design procedure.

The system characteristics are,

	Pond 1	Pond 2	Pond 3
Area ha	1.2	0.73	0.73
Volume m^3	24,000	13,900	13,200
Depth m	2.0	1.9	1.8
Freeboard m	0.6	0.6	0.6
Sideslope	3 : 1	3 : 1	3 : 1
Approximate detention time	8 days	5 days	4.5 days
Approximate BOD_5 loading	400 kg/ha/day		

The approximate flow rate is $3,000m^3$/day and the raw sewage is purely domestic, and is pumped to the pond system where primary treatment is carried out in two settling tanks.

There are no special facilities for dealing with temperature variation or prolonged cold periods.

c) The ponds are constructed on a lateritic soil which was used in the embankment construction. There are no apparent problems of embankment subsidence although the embankments have suffered some erosion since there is no hard edge detail. Submerged inlets and outlets are provided in all the ponds with an interconnecting concrete lined channel which includes a V notch in each case. The system is provided with a bypass and each pond has facilities for drain down.

Preliminary treatment is provided by a manually cleaned bar screen and two settlement tanks.

d) The embankments are planted with grass, access to the ponds is good but vehicular access around the ponds is difficult.

e) Fencing is provided with 5 strands of barbed wire 1.5m high.

f) There is no laboratory although a concrete sampling platform has been constructed over the outlet from the primary pond.

g) Gross area of site is 7.4ha
Net area of ponds is 2.7ha
The ponds are located in marginal farm land and there would appear to be room for further extension of the system if this were required. The nearest residential neighbourhood is 200m away and the nearest main road 1km.

h) There are some catfish in the ponds but no ancillary use has been seriously considered.

i) There is no official reuse of the effluent.

j) The costs at time of bidding are not available.

4.2 Bidding.

The list of bids received and description of procurement process are not available.

4.3 Construction.

Description of the construction methodology employed, range of equipment used, compaction control and the total actual costs are not available.

4.4 Operation.

a) No information is available on start up procedures or smell in early stages.

b) There are 3 labourers based at the Chelston ponds. They are not trained and there are no organisation or maintenance manuals.

c) Operational costs are mainly wages and are approximately 3,000 Kwacha per annum.

d) Occasional monitoring of pond performance in terms of the major physical, chemical and biological criteria is carried out by the laboratory staff based at the Manchichi treatment works. The most recent data suggests the effluent quality is,
BOD_5 40 mg/l
S.S. 70 mg/l
The required effluent standard is the Royal Commission standard of,
BOD_5 20 mg/l
S.S. 30 mg/l

One investigation of the bacteriological quality of the effiuent showed 6,000 EColi/100ml.

Sl udge removal from the primary pond was carried out after 10 years of operation without problems.

There are some problems of weed growth at the water surface edge and some algal scum formation was observed. Slight erosion problems have been caused by the absence of embankment protection.

There are no special facilities for coping with enhanced flow, effluent change or overloading.

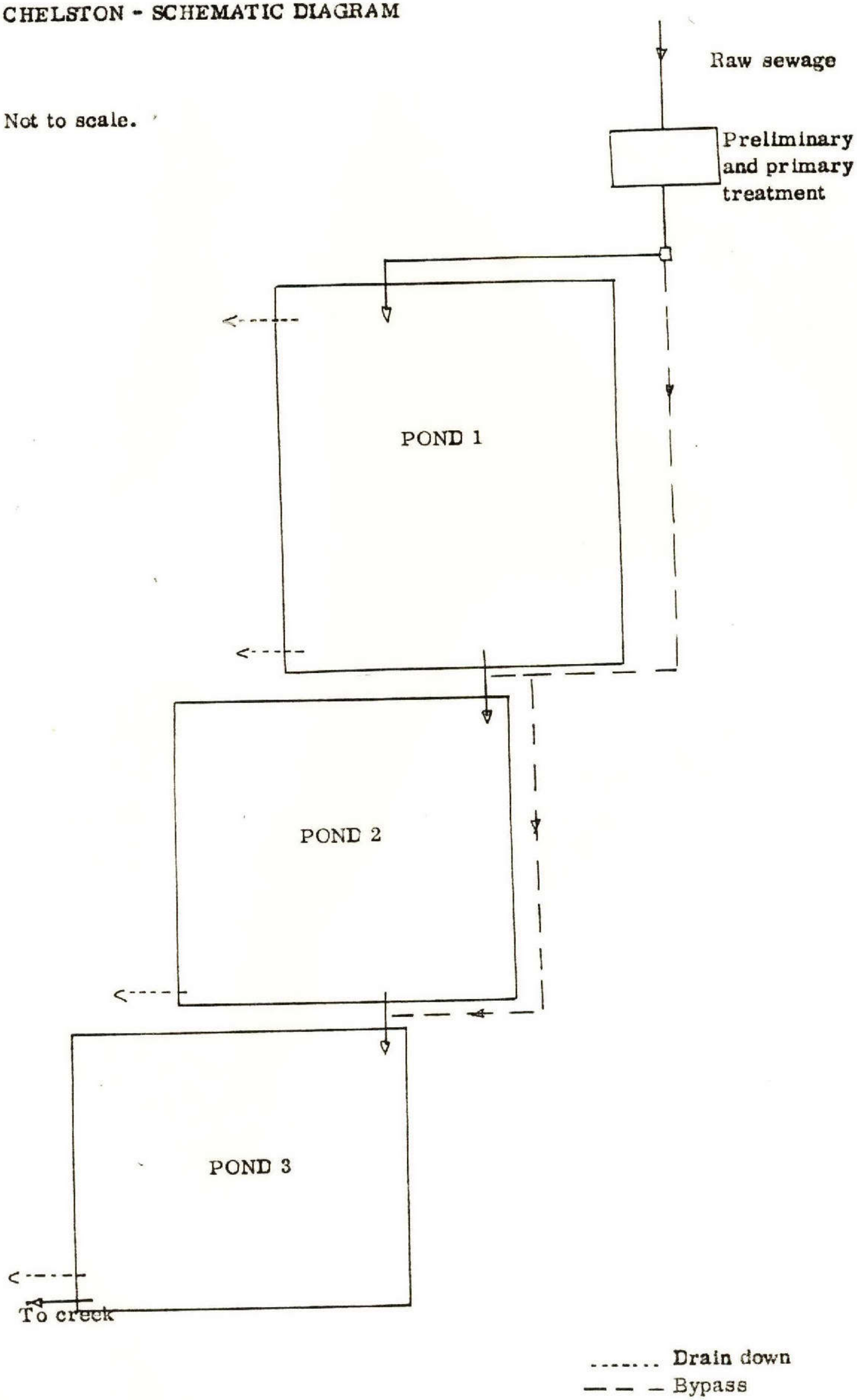
e) The City Council is finding no problems with the operation of the Chelston system.

f) There is no effluent reuse.

g) There is no effluent chlorination.

CHELSTON - SCHEMATIC DIAGRAM

Not to scale.



C4.5 MUNALI, LUSAKA.

5th June, 1981.

Client: Lusaka City Council

5.1 Design.

a) There was no resistance to the use of ponds.

b) The pond system comprises one facultative and two maturation units, designed on an empirical basis. The physical characteristics of the pond system are as follows:-

	Pond 1	Pond 2	Pond 3
Area ha	2.5	1.25	1.25
Volume m^3	35,000	18,700	20,000
Depth m	1.4	1.5	1.6
Freeboard m	0.3	0.3	0.3
Slope	1 : 2	1 : 2	1 : 2
Detention time in each pond	11.5 days	6 days	6.5 days
Approximate BOD_5 loading rate	260 kg BOD_5/ha/day.		

The approximate flow rate of raw sewage is 3,000m^3/day and it is purely domestic.

There are no special facilities for dealing with termperature variation or prolonged cold periods.

c) The ponds are constructed in lateritic soil which is also used in construction of the embankments. There is no evidence of percol ation or leakage problems although no pond lining was provided. There is no embankment protection and some embankment erosion has been caused.

Surface outlets from the ponds are used and all inlets are submerged.

Pretreatment is provided by bar screen and grit channels, and a flow measuring weir is provided at the inlet to the first pond.

A bypass is provided for Pond 1 only, and no drain down facilities are provided for any of the ponds.

d) There is no fencing.

e) The embankments are planted with grass. Access to and around the ponds is good. The embankment dividing ponds 1, 2 and 3 is too narrow to allow vehicular access.

f) There is no lighting.

g) No laboratory is provided.

h) Gross area of treatment site 12ha.
Net area of ponds 5 ha
The pond system is situated in marginal farm land about 500m from the nearest housing and 1 km. from the nearest main road.

i) There are catfish in the ponds but there is no ancillary use.

j) There is no effluent reuse.

k) Costs at time of bidding are not available.

5.2 <u>Bidding</u>.

The list of bids received and description of procurement process was not available.

5.3 <u>Construction.</u>

Information on the construction methodology, plant used in construction, and total actual cost was not available.

5.4 <u>Operation.</u>

a) No information was available on the start up procedures employed or on any odour problems in the early stages of operation.

b) There are only two employees working at the Munali pond system, both of whom are labourers. There is no staff training, and organisation and maintenance manuals do not exist.

c) The operational costs are mainly for labour, and are equal to about 2,000 Kwacha per year.

d) There is no regular performance monitoring system, and the records from the laboratory suggest that no samples have been taken at Munali for some time.

There are some maintenance problems at the plant due to a large volume of sand having found its way into the first pond. This is obstructing the inflow and causing the collection of solids on the surface near the inlet. Some vegetation and scum has collected around the edge of the ponds, and evidence was found that mosquito breeding is occuring in this material.

The Royal Commission 30 : 20 standard is specified for the final effluent from Munali,but it is unlikely that this standard is being achieved due to the algae in the effluent.

There are no facilities for dealing with enhanced flow, effluent change or overloading, and the flexibility of the system is limited to the bypass.

e) The Lusaka City Council is quite happy with the ponds as a viable treatment system.

f) There is no reuse experience.

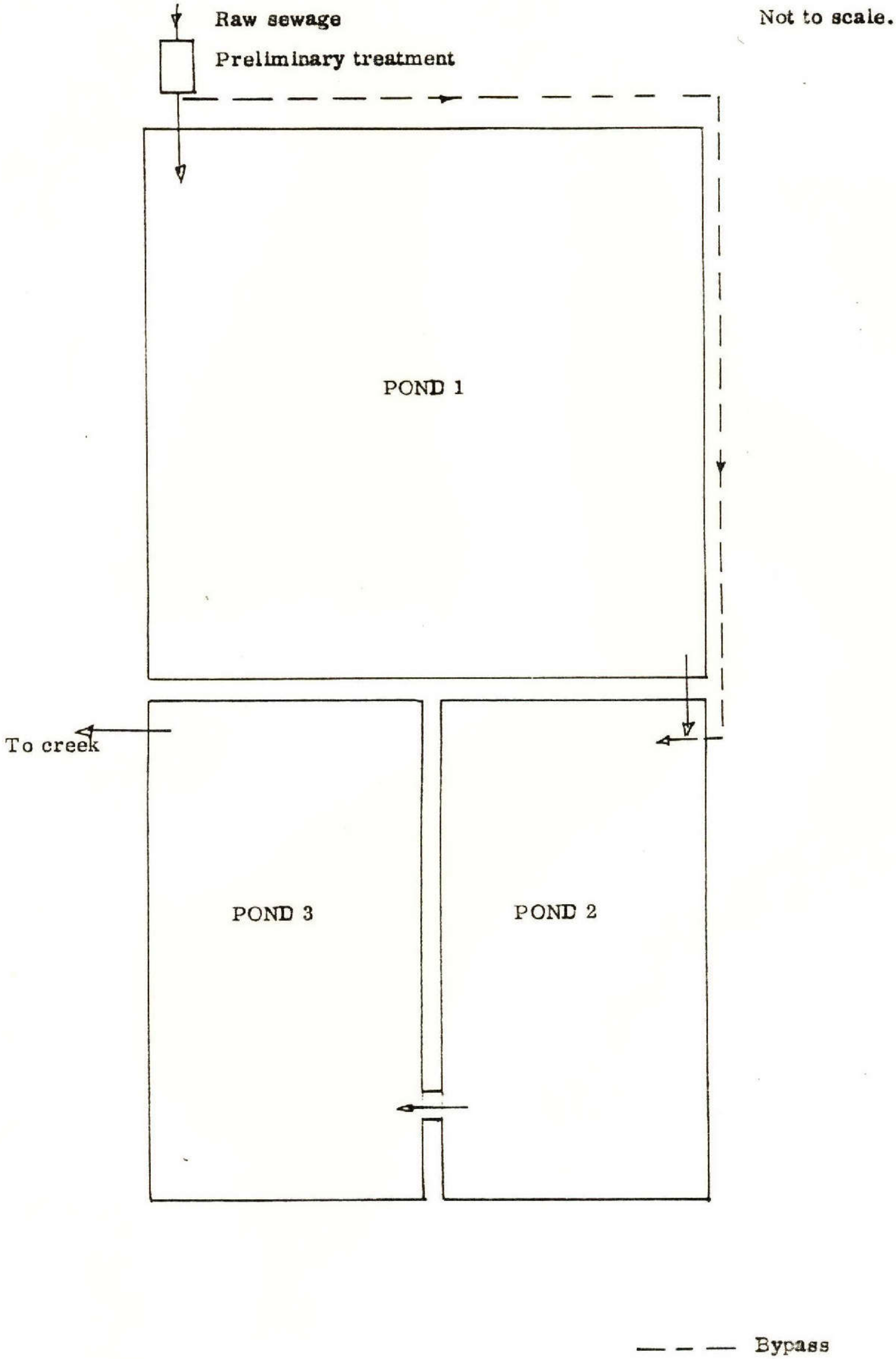
g) Chlorination is not carried out.

5.5 Problems and Recommendations.

The first pond should be emptied and the accumulated sand and sludge dried and removed.

The maintenance should be improved to avoid accumulation of vegetation and scum around the pond edge and consequently avoid mosquito breeding.

MUNALI - SCHEMATIC DIAGRAM



C5.1 DE LA VEGA, SPANISH TOWN, JAMAICA

June 20th - 26th, 1981

Client: Sites and Services Division of the Ministry of Housing.

1.1 Design.

a) The sites and services division of the Ministry of Housing appears to have had no objection to the use of waste stabilization ponds for the treatment of sewage from the De La Vega housing project. However, objections were raised to the use of a pond system by the then National Water Authority (now Water Commission) to whom the pond design was submitted for approval. Their objections were as follows:-

i) Likelihood of odor nuisance.
ii) Poor effluent quality.
iii) A request for a sample of the final effluent to be analysed in their laboratories before the ponds were constructed.

The pond system at Spanish Town appears never to have been approved by the National Water Authority.

b) The pond system was conceived in a feasibility study and preliminary design for waste stabilization pond treatment of liquid wastes from the Spanish Town sites and services project. The report was produced in 1973 by W.J. Oswald, and various treatment alternatives were considered. These were:-

i) A pond system.
ii) An activated sludge package plant.
iii) A Pasveer (oxidation) ditch.
iv) A trickling filter system.

Each system was evaluated in terms of:-

i)	Effectiveness	- Quality - Reliability - Fail Safety
ii)	Construction	- Speed - Complexity - Materials - Labour
iii)	Salvageability	- Land - Equipment
iv)	Reclaimation	- Water - Nutrients

Based on experienced judgement, a relative scale was applied to each factor. The 'scales' thus obtained were:-

Pond system	108
Pasveer ditch	77
Trickling filter	48
Activated sludge	47

For evaluation of costs four levels of pond system were considered, these were:-

i) Costly - high cost assumption, including pump station.

ii) Moderate - medium cost assumption, including pump station.

iii) Low - low unit cost assumption, no pump station.

iv) Minimal - low unit cost assumption, free land, no levee protection and no pump station.

Using estimated capital and operation costs the cost per housing unit per year for the different treatment systems were:-

Pond system	- costly	100	Jamaican dollars
	- moderate	82	" "
	- low	45	" "
	- minimal	32	" "
Activated sludge		95	" "
Trickling filter		92	" "
Pasveer ditch		83	" "

The design assumptions for the pond system were as follows:-

TABLE C5.1.1	Design Assumptions
Contributing population	3,360
Initial average flow	135,000 U.S. g.p.d.
Ultimate average flow	202,000 U.S. g.p.d.
$B.O.D._u$ contribution	0.2 lb/capita/day
Estimated ultimate B.O.D. load	670 lbs.
Mean daily solar energy	214 langleys
Minimum mean monthly average temp.	77^oF (25^oC)

The area of the primary pond is based on gas production

$$G = 450(T-15) = 4,500 \text{ ft}^3\text{/acre/day}$$

or, using a safety factor of 1.33, 3,380 ft^3/acre/day.

Since 1 lb. B.O.D. yields 10 ft^3 of gas, 338 lbs. of B.O.D. destroyed.
Since total B.O.D. load = 670 lb., 2 acres required for primary pond.

The primary pond depth is calculated on the basis of 20 days detention time to give required coliform die away at 25°C. The freeboard is based on one month's rainfall.

The total area of the pond system is based on satisfaction of the B.O.D. by photosynthetic oxygen.

The assumptions made are:-

Minimum average light intensity	160 langleys
Photosynthetic efficiency	4 %
Ratio useable oxygen to total produced is	1:1.6

The total area required is 7 acres reduced to 6 acres to allow for the 60% B.O.D. removal through methane fermentation.

Second pond designed to have the same area as pond 1 with loading rate of 80 lbs. B.O.D. per acre per day. Third pond designed for 60 lbs. B.O.D. per acre per day, and fourth making up the balance of the area, which makes them 1 acre each.

Designed pond characteristics are:-

		Pond 1	Pond 2	Pond 3	Pond 4
Area	ha	0.8	0.8	0.4	0.4
Volume	m^3	2400	2400	1200	1200
Depth	m	3	3	3	3
Freeboard	m	0.6	0.6	0.6	0.6
Slope - interior		1:4	1:4	1:4	1:4
- exterior		1:2	1:2	1:2	1:2
Planned detention time	days	20	20	10	10
Planned $B.O.D._5$ loading	kg/ha/day	360	90	67.2	-

Predicted performance of the pond system is as follows:-

Discharge characteristics		Average	Maximum
Settleable solids	mg/l	0.2	0.5
$B.O.D._5$	mg/l	20	30
MPN per 100 ml	(coliform)	100	1000
Suspended solids		30	40

The design of the pond system was modified in 1975, and was constructed with the following characteristics.

Actual Pond Characteristics.

		Pond 1	Pond 2	Pond 3	Pond 4
Area	ha	0.84	0.84	0.42	0.42
Volume	m^3	16,000	10,000	5,400	5,400
Depth	m	2.4*	1.6	1.6	1.6
Freeboard	m	0.6	0.6	0.6	0.6
Sideslope					
- inside		1:4	1:4	1:4	1:4
- outside		1:2	1:2	1:2	1:2
Detention time					
- design	days	13	10	6	6
- actual	days	25	20	?	?
Loading rate					
- design	kg BOD_5/ha/day	360	90	-	-
- actual	kg BOD_5/ha/day	190	-	-	-

* Sump at inlet of 3.6m depth.

Further modifications were made to design after initial construction. These modifications comprised mainly bitumen sealing of the primary pond and alterations to the inlet, outlet and interpond connection structures.

No particular problems were foreseen with percolation and evaporation, although percolation has proved to be a problem.

No special procedures were adopted for coping with prolonged cold periods or temperature variation (which is small in any case).

The wastewater constribution from commercial and industrial establishments is minimal.

c) The pond system is constructed in a disused gravel quarry, and the soil consists of interbedded gravel and silty clays. The clayey soil excavated in pond construction was used to construct and line the embankments. Information on the degree of compaction achieved was not available, but no particular problems have occurred as a result of poor compaction.

Considerable percolation has occurred as each pond is brought into use. This has resulted in a very slow filling of the pond system.

None of the ponds are provided with levee protection although some areas of the embankments of pond 1 have been concreted as a remedy for erosion problems.

A bypass is provided for pond 1 only, to facilitate pond cleaning when this becomes necessary. No flow measuring devices are provided, but a manually cleaned screen is located upstream of the syphon which carries the raw sewage under the Rio Cobre river.

Submerged inlet and outlet structures are used, replacing the original surface outlets. The inlet pipe to pond 1 runs to the centre of the pond.

d) Chain link fencing is provided, supported by tubular steel posts at 3.5m intervals. The chain link fencing is 2m high and is topped by 3 strands of barbed wire.

e) The embankments are vegetation covered on the inside and outside, and 'bushing' takes place every few months. The access road around the embankments is impaired by the vegetation and poor surface which is clayey although a 200mm Marl surface dressing was specified.

f) There is no provision for lighting.

g) A simple blockwork building has been constructed to serve as a laboratory, but this has been stripped of roof and facilities.

h)

Gross area of treatment site	4	ha
Net area of ponds	2.52	ha

No reserved land exists,
The site was selected for its proximity to the community served by the pond system and to minimise earthworks required. The pond system is 100m from the nearest residential neighborhood and 50m from the nearest main road.

i) No consideration has yet been given to fish farming or algal harvesting.

j) There is no effluent reuse planned, and when effluent does become available it will be discharged to the Rio Cobre river. Irrigation of sugarcane is a possible method of reuse although the problems of soil pore clogging by algae will need some attention.

k) The estimated costs before bidding were the costs used in the feasibility study for the site chosen. Depending upon the inclusion of pond lining and levee protection two prices were given:-

With lining and protection	\$ 181,000
Without lining and protection	\$ 123,000

The main contractor for the sites and services project included a provisional sum of \$ 145,000 for the pond system. No information was available on the clients estimated costs before the contractor was asked to tender.

1.2 Bidding.

The contract for the construction of the ponds did not go out to competitive bidding. The main contractor for the whole sites and services project was asked to tender for the following reasons:-

i) The pond system was already included in the contractors' price for the complete project, as a provisional sum of $ 145,000.

ii) The contractor was already established on site which should have resulted in reduced preliminary sums.

iii) Previous experience of the contractors work has shown it to be satisfactory and on schedule.

The first sum submitted by the contractor was $313,692.47. This sum was reduced in stages, first by cutting preliminaries and the rate per cubic yard for cut and fill giving $274,154.13, then by a further cut in the rate for cut and fill to give $253,132.00.

1.3 Construction.

Little information was available on the construction methodology, equipment used and compaction control. The earthworks were carried out using 2 scrapers and D8 dozers, and were subcontracted by the main contractor. Some problems were encountered and cost overruns incurred in construction of the pipework and structures. The total cost overruns were within the allowance for contingencies. No information was available on the unit costs or total actual cost of construction.

Modifications to the inlet and outlet structures were required in 1980 due to poor details for the original pond transfer pipes. The inlet to pond 1 became blocked and the pond required pumping out before the blockage could be cleared and the pipe repaired. The total cost of these remedial works was $41,586.59.

1.4 Operation.

a) The planned start up procedures included the filling of all the ponds with water from the Rio Cobre river and the seeding of the ponds with raw sewage. The filling of the ponds with river water could not be carried out because the pump was stolen from the river. The ponds were seeded with 300,000 gallons of fresh sewage costing $5,800. Due to the high percolation experienced at the ponds, a large proportion of the sewage was lost almost immediately.

There have been no major problems during start up, except that in spite of operating for over one year the ponds are not yet full because of the high percolation rate.

b) There is no permanent staff at the pond system except for one operator who looks after the screen, cleaning it several times a day. Since the screen is across the river from the pond system, he does not visit the system itself. There is one watchman looking after the pilot scale high rate pond which has been constructed adjacent to the existing ponds by the Water Commission. His responsibility appears not to extend to the main pond system. Maintenance is carried out by a team of about four labourers who remove large plants and bushes from the pond embankments every 3 or 4 months. Maintenance is currently the responsibility of the Ministry of Housing but will eventually be carried out by the Water Commission.

   There is no staff training, nor are there any organisation or maintenance manuals.

c) The operational costs comprise only the labour cost of the screen operator and the 'bushing' gang. This might amount to about $ 10,000 per year.

d) There is no existing or planned pond monitoring system. Some measurements of nutrient concentration have been made but no BOD or bacterial counts have been carried out. The effluent standard required is 20 mg/l BOD_5 and 30 mg/l S.S., but no final effluent has flowed from the pond system to date.

   Some smell was noted at pond one, probably due to algal scums which have formed on the pond surface and have not been broken up. Weed growth is a problem on the inside embankments due to poor maintenance and the lack of a hard edge detail.

   There is no record of pond changes during high winds or cold weather, wave action appears to be causing only minor erosion problems, due largely to the thick vegetation at water surface level.

   There are no special provisions for enhanced flow, effluent change or cases of overloading. The capacity of the system to absorb shock loadings is high due to the long detention times used. The flexibility of the system is restricted to the ability to bypass pond 1 and make pond 2 the primary unit.

e) The implementing agency seems perfectly happy with the pond system although it is not yet fully operational.

f) There is no experience of effluent reuse.

g) There are no plans to chlorinate the final effluent.

1.5 Status and Problems.

The pond system has been operating for more than one year but so far only ponds 1 and 2 are full and pond 3 half full. The slow filling of the system appears to be due to the following factors:-

i) The plots on the sites and services area have been progressively filled over the past two years, which has meant a gradual increase in the wastewater flow. Only three quarters of the sites are currently occupied, and thus the wastewater flow is still less than the design flow.

ii) Percolation from the ponds appears to have been considerable, probably due to the high proportion of gravel in the soil. However, there is evidence that both ponds 1 and 2 have now largely sealed themselves.

A high rate pond with a detention time of 2 days has been constructed adjacent to the existing pond system by the Water Commission. This pond will be used for a pilot project on the operation of highrate ponds, and will draw effluent from pond 1 and discharge into pond 3.

The standard of maintenance at the existing pond system is poor and should be improved. Steps should be taken to avoid further damage to the pond structures, and to prevent additional sections of the fence being taken.

1.6 Remedial Measures.

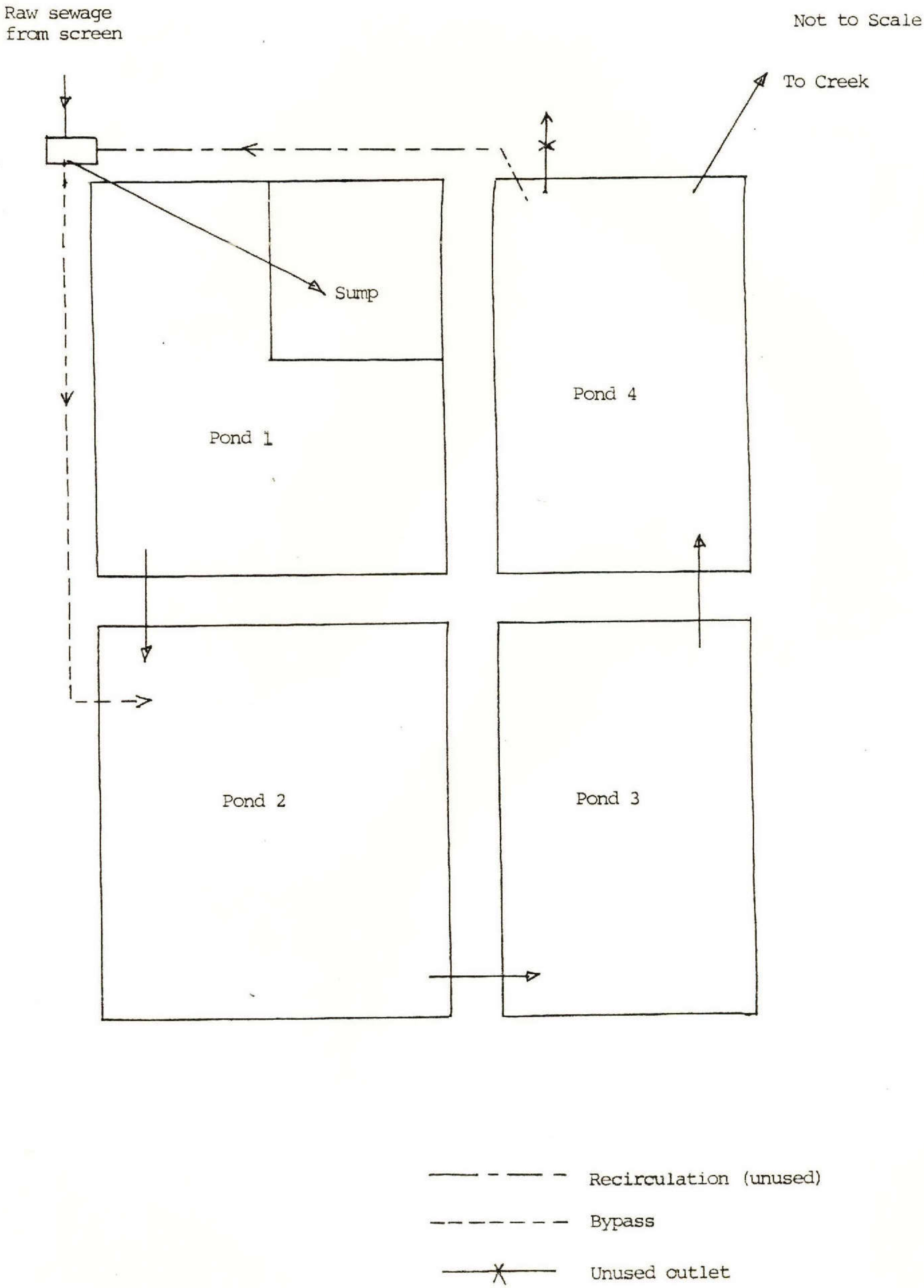
i) Maintenance staff should be permanently assigned to the pond system to perform routine maintenance, such as vegetation removal and algal scum removal.

ii) Watchmen should be employed if the building is repaired and the fence replaced. When the fence is replaced, it should be spot welded to the fence posts, if possible.

iii) The screenings should be buried rather than being disposed of to the ground, which is currently the case.

iv) Care should be taken to ensure that the removal of effluent from pond one for the pilot high rate pond, will not result in pond two becoming completely idle.

SPANISH TOWN - SCHEMATIC DIAGRAM



ANNEX D -

D1. EAST CALCUTTA DEVELOPMENT PROJECT,
WASTE TREATMENT SYSTEM, CALCUTTA, INDIA.

May 16th - 19th, 1981.

Client: Calcutta Metropolitan Development Authority
Bank Financed.

1. Status and Design.

The waste stabilisation pond system which was to have treated the wastewater from the East Calcutta township and service village has now been superceeded, the system now proposed is a trickling filter sewage treatment plant comprising,

i) Preliminary treatment by screening and grit removal in detritor tanks.
ii) Primary clarification.
iii) A two stage fast rate biological filter.
iv) Secondary clarification.

A system of recirculation will operate between the outlet of the first biological filter and the primary clarifier inlet, of the secondary biological filter.

The background to this fundamental change in the design of the treatment system is set out below. Because of its complete inappropriateness to the situation in Calcutta, the standard field note format is not used in this case.

a) The report completed in 1979 for the World Bank by Dr. G.D.Agrawal entitled 'East Calcutta Integrated Wastes Recycling and Service Village Project' made the following recommendations.

i) Out of three systems for waste recyling, all using waste stabilisation ponds for wastewater treatment, and two also using biogas plants to produce biogas from cattle dung, one was recommended.

ii) This system was designed for a township population of 40,000, a service village population of 2,500, a cattle population of 5,000 head and a washermans community of 1,700.

iii) The system comprised:
- A preliminary treatment system of bar screens and two parallel grit channels.
- 2 no. primary settling tanks from which the sludge was fed to the biogas mixing tank and thence to the digestor.
- A system of anaerobic, facultative and maturation ponds occupying a net area of 12 ha. These have sufficient capacity to allow both sewage and cow dung to be treated in the ponds should it become necessary to bypass the biogas plant. Even under these conditions and with a further 20,000 projected population in the township, the pond design remained rather conservative (see below).

- The feeding of waste stabilisation pond effluent to the fish ponds to provide make up water and fish food in the form of algae.
- Recycling of part of the maturation pond effluent after passing through horizontal flow filters and undergoing chlorination to give a free residual of 0.5 mg/l after 30 minutes contact time. The recycled effluent would be used for cattle washing and by the washermen.
- The cattle dung would be collected 4 times a day, mixed with the primary sludge and digested for an average 10 day detention period.
- Digested sludge would be dried and sold as fertilizer, the gas would be used for domestic purposes and to maintain the digester temperatures at 35°C, run pumping equipment, and be supplied to the washermen for water heating.

b) Following approval by CMDA and the World Bank of this scheme, the engineering consultants Architects Collaberated were employed to produce detailed designs of the treatment elements. Basing their design on CPHERI guidelines and Indian standard No. 2296 of 1976 they presented their preliminary designs for the waste stabilisation ponds and biogas plant. Their report submitted to CMDA in July 1979 included the following,

i) Description of overall water reuse system including planned system for recycling water to supply 180 litres per buffalo per day and 1300 litres per washerman per day.

ii) Brief outline of some operating experience of waste stabilisation pond systems in India, including reports of loading rates of 1100, 1200 and even 8800 lb BOD_5/acre/day being satisfactorily applied to give first order BOD_5 removal rate constants (base e) of 0.282 to 0.427.

iii) Outline design of the pond system based on empirical data from C.P.H.E.R.I. but ignoring the successful operation of ponds at high loading rates as given above. The system comprised parallel series of anaerobic facultative and maturation ponds and assumed a first order BOD_5 removal rate constant of 0.3. Other design assumptions were an influent BOD_5 of 510 mg/l and a total daily flow of 18,000m^3. The assumed detention times and total mid-depth areas of the system are shown in Table D.1.

TABLE D.1. W.S.P.Design Criteria.

Pond	Detention time	Loading Rate	Area	Depth.
Anaerobic	5 days	0.1 $kg/m^3/day$	3ha	3.0m
Facultative	5 days	612 kg/ha/day	6ha	1.5m
Maturation 1	3.2 days	380 kg/ha/day	3.9ha	1.5m
Maturation 2	3.2 days	196 kg/ha/day	3.9ha	1.5m
Maturation 3	3.2 days	98 kg/ha/day	3.9ha	1.5m

The final effluent is predicted at 19.5 mg/l BOD_5, and total area requirement for the pond system estimated at 24ha.

iv) The pond effluent was to be fed to the fish ponds and 3,110 m^3/day recycled for the washermen and cattle shed washing. This water was to be drawn from the last fish pond and passed through a pebble bed clarifier and slow sand filter before being chlorinated to give a residual of 0.5 mg/l after 30 minutes.

v) The outline design for the biogas plant was also presented in this document which was submitted to C.M.D.A. for their comments in March 1979. They responded by requesting Architects Collaberated to submit a report on alternatives to pond treatment in view of the large amount of land required for the pond system and high cost of the land (claimed to be Rs 1,500,000 per ha).

c) The report outlining the treatment process alternatives was submitted to C.M.D.A. in July, 1979, and considered the following processes.

i) Primary clarification, chlorination and discharge.

ii) Pump raw sewage to another proposed plant.

iii) Chemical coagulation, flocculatio nand carbon absorption.

iv) Primary clarification and discharge to W.S.P.s.

v) High rate trickling filters preceeded and followed by clarification.

vi) Activated sludge plant.

vii) Trickling filters followed by activated sludge plant.

Of these, the first four options were rejected for various reasons, option 4 because of,

i) Algae in effluent infringing the U.S.A.'s E.P.A. effluent standards.

ii) A lack of information on pond operation.

iii) Adverse remarks on the use of ponds from the U.S.A.

iv) The 'mixed' success of ponds in Africa.

and v) The excessive land requirement.

The other three options (5, 6, and 7) are considered in detail with approximate capital and operational costs being evaluated. The capital costs were calculated as follows,

i)	High rate trickling filters	Rs 6,380,000
ii)	High rate trickling filter plus activated sludge process	Rs 6,439,000
iii)	Activated sludge plant	Rs 6,500,000

Thus for reasons of cost, simplicity of operation and experience from existing plants the report recommended high rate trickling filters.

d) C.M.D.A. duly accepted this option and Architects Collaberated produced a detailed design which, with slight modifications has now been approved by C.M.D.A. since February, 1980. The main features of the treatment system are mentioned above, and the design assumptions are,

i) Populations:

Main township	41,500
Service village	10,320
Outlying areas	20,000
Washermens units	1,700
Cattle	5,000

plus the industrial area.

ii) The following water consumptions, wastewater flows and BOD_5 contributions:-

TABLE D.2.

	Water consumption	Wastewater flow	BOD_5 Contrib.	BOD_5
Main township	225 l/c/d	7,470	45g/cap/d	3360 kg
Service Village	115 l/c/d	950	"	
Outlying areas	225 l/c/d	3,600	"	
Washermens units	1,300 l/c/d	1,770	500 mg/l	850 kg
Cattle	270 c/animal/d	1,100	850 mg/l	918 kg
Industry	17.8 kl/ha/d	235	125 mg/l	30 kg
Infiltration	18.9 kl/ha/day	2,500	-	-
Filtrate from sludge drying				60 kg
Totals		17,725 m^3/day		5200 kg/d

this assumes 80% recovery rate for wastewater, and gives a raw sewage BOD_5 of 290 mg/l, considerably less than the 570 mg/l assumed for the waste stabilisation pond design.

Using a peak factor of 2.4 the hydraulic design of the preliminary treatment is carried out using standard empirical formulae. Similarly the clarifiers and trickling filters are designed using standard loading rates and assuming 30% BOD_5 removal in the primary clarifiers. Hydraulic loadings on the trickling filters and clarifiers are calculated using the Rankine formulae and assuming a total recirculation rate equal to the average hydraulic loading rate.

In addition detailed designs were produced for the biogas plant using the following design assumptions.

i) Cattle dung produced: 10kg/animal with 5% lost in washings, dung assumed to have a solids proportion of 20% of which 80% are volatiles. Of these 30% are assumed to be reduced in digestion.

ii) With digester temperature maintained at 35°C gas production is assumed at 1.4 ft^3/kg.

iii) Sewage sludge used is assumed to amount to 38 grams per capita per day with a solids content of 5%. The volatile solids proportion is assumed at 65% providing 8 to 12 cu.ft of gas per pound of volatiles.

iv) Balance of dung and sludge gives 145,420 kg/day at a solids content of 10%, and with two digesters giving 18 days sludge detention each is 1275m^3 in volume.

v) Two mixing tanks are also provided with a volume of 35.4m^3 each and a boiler of 400,000 Kcal /hr capacity is required to keep the digester temperature at 35°C.

Due to the problems associated with the operation and use of dual water supply systems the proposal to recirculate the effluent was dropped.

e) The tender documents have now been prepared for the treatment plant and biogas plant by Architects Collaberated. However, the tender document states that,

"(The) contractor can submit any design of his own excepting for a stabilisation pond system, oxidation ditch or extended aeration process".

Cost estimates for the proposed treatment plant are as follows:-

		Rs
Civils Cost:-	Earthworks	470,275
	Concrete, brick, masonry	2,730,558
	Flooring	194,489
	Structural steel	32,200
	Down pipes chimneys	2,350
	Plastering	40,053
	Painting, varnishing	2,268
	Whitewashing etc.,	12,415
	Miscellaneous	499,114
Main Plant total Civils		3,983,723
	Office, Control room, pump house etc	1,071,706
	Roadways, wall, gate	950,778
	Total Civils	6,006,207
	Sanitation and plumbing	22,597
	Electrical and Illumination	306,096
	Total	6,328,900

The estimate is arrived at using standard government rates.

f) Contractors will be prequalified and chosen so as to ensure that as many as possible will be in a position to propose their own treatment system. The lowest bid for any approved treatment system will secure the contract.

g) In order that gravity flow may be maintained throughout the system (except for recirculation) the preliminary treatment works will have to be constructed 6m above existing ground level.

h) Assuming a population equivalent served of 100,000 (180 l/c/d waste water contribution) the cost per capita of the system is Rs 63 per capita or $8 at current exchange rates.
Or considering the actual population served of 78,250, Rs 81 per capita or $10 at current exchange rates.

It should be stressed that these costs are estimated at 1980 prices.

2. Other Physical Factors.

2.1 The fish ponds have been constructed and some value is attached to considering aspects of fish pond construction which would also apply to construction of any waste stabilisation pond system.

i) The soil is silty clay with a low permeability and as a result the fish ponds are not lined.

ii) Excavation of the ponds was carried out by hand at the rate of Rs 17.6 per m^3. Embankment construction was also by hand with no compaction control. As a result compaction of the embankments appears to be poor with voids visible at the surface. Where subsidence occurs additional material is added to bring the surface back to level. A smooth wheeled roller is used to compact the surface layer on the top of the embankment to allow vehicular access.

iii) The fish ponds are not provided with a hard edge detail, although turfing to the water line is the traditional method of obtaining embankment stability. Wave protection is probably not crucial on ponds of this size, although would be on the large stabilisation ponds.

2.2 The proposed conventional treatment plant will be provided with the following:-

i) Lighting comprising tubular steel poles 8.5m in length and bedded in concrete foundations, with lights supported by an arm cantilevered from the top of the pole. Lights used are, 32no. 2 x 40 watt florescent street light luminaires, 6no. 1000 watt incandescent flood light luminaires, and , 2 no. 500 watt incandescent flame proof flood light luminaires.

ii) A perimeter wall, 1.8 metres in height and brick built.

2.3 The final effluent discharge will have to conform to the relevant standard for the discharge of effluent to a watercourse, which in this case is 30 mg/l BOD_5 and 100 mg/l suspended solids. There is no bacteriological standard.

3. <u>Discussion</u>

3.1 The client (C.M.D.A.) appears to have initially been in favour of ponds at East Calcutta and still claims that they would like to use them. However, due to the pressure on the land available they feel that the trickling filter system is more appropriate. Furthermore other trickling filter treatment plants are claimed to be working quite satisfactorily in and around Calcutta and thus C.M.D.A. do not foresee any operation and maintenance problems. The objections to use of ponds were,

i) The cost of land at 15 lacs of Rupees (Rs 1,500,000) per ha.

ii) Public reaction to the use of this land for treatment ponds.

iii) The high demand for land for housing in the area.

and iv) The proximity of the treatment plant to residential areas.

v) The high operational cost when the loan repayment is included.

Other objections raised at a meeting held with the design engineers from Architects Collaberated on May 19th were,

i) The CPHERI guidelines for waste stabilisation pond design (1972) state that Rs 55,000 per acre(compared to Rs1,500,000 for East Calcutta) is the maximum price at which waste stabilisation ponds may be considered as the most economical treatment system.

ii) In reply to suggestions that the area could be reduced by increasing the loading rates it was clained that nuisance was observed from one pond system operating with loading rates higher than those recommended by CPHERI (Now NEERI).

iii) In reply to suggestions that area reductions could be achieved by deepening ponds it was claimed that best results are obtained from ponds with depths less than 1.8m.

iv) In reply to suggestions that some of the maturation ponds could be left out and effluent from secondary and tertiary ponds provided directly to fish ponds it was claimed that in such cases the fish suffer from the high suspended solids content.

3.2 The high cost of land in the East Calcutta area appears to severely restrict any possibility of using waste stabilisation ponds as a treatment system. However, there do appear to be unanswered questions with respect to the current posposal, and possibly ways in which the fish ponds and any potential waste stabilisation pond system could have been combined to reduce the total areal requirement.

i) Soil to build up some areas of the site has been taken from what is now a barrow pit 5 or 6 metres deep and 10ha in area. These excavations are to be used as a sump for water used by the washermen. A sump of much smaller dimensions would suffice, and material could instead have been excavated from the proposed treatment plant site. This would have provided the dual advantage of a deep anaerobic pond, and a reduced area of 'wasted' land which cannot, at the moment, be used for anything.

ii) Although the proposed pond system occupied 24ha, as opposed to 4.5ha for the trickling filter plant, only 9ha of the 24 was for the anaerobic and facultative units. Were the maturation units to be omitted and the effluent from the facultative pond to be distributed amongst the fish ponds (with a total area of 50ha) it is highly unlikely with such a low organic loading that the ability of the fish ponds to remain aerobic throughout the day would be in any way reduced. Furthermore, although the effluent from the facultative pond would be unlikely to achieve the stipulated 30 : 100 standard, the effluent from the fish ponds (about 12,000m^3/day allowing for percolation and evaporation) undoubtedly would. Thus rather than the treatment system and fish ponds being separate entities, the two are combined, the fish ponds providing maturation units with a total detention time in excess of 80 days.

iii) A further advantage of the system being run in this way would be the additional nutrient provided to the fish ponds. In should be noted that although the original report (Argrawal) made provision of algae to the fish ponds an important source of fish food, no such algae will be present in the effluent of the trickling filter plant.

PILOT PROJECT PROPOSAL:

ELECTRICITY CONNECTIONS TO LOW-INCOME HOUSEHOLDS

Tim Campbell, Consultant
LEC
Monrovia, Liberia

March 13, 1981

TABLE OF CONTENTS

EXECUTIVE SUMMARY AND RECOMMENDATIONS

This report considers two alternatives for delivering minimum electricity service on an experimental basis to low-income households at a minimal cost to both the customers and the LEC. The chief aims in these proposals are to implement social and technical controls over energy consumption and illegal use of electricity while improving the quality of service.

The report argues that certain low-income neighborhoods are willing to cooperate in an experimental project in which cheaper electricity and better service are exchanged for a commitment by local residents to honor their obligations and regularly pay their electric bills.

Reduced tariffs, deposits, and connection fees are indispensible in this scheme. Reductions in rates may be rationalized on grounds of efficiency (in reducing losses, sharing costs, and inducing less profligate use of energy) and on grounds of equity (in shifting the burden of payment to those better able to pay, e.g. the commercial sector). Research needs to be done to calibrate the effects of tariff changes.

A block-metering scheme is proposed by which power is delivered to portions of a selected neighborhood (Claratown, approx. 800 households) meter in blocks of about 10, The first phase of this plan would begin with about 10 clusters of blocks. Community residents have expressed interest in participating in this plan.

Residents of the community would be responsible for organizing block committees to allocate monthly bills among the block members, to help collect revenues, keep records, and to guard against and be responsible for, illegal connections. A community-wide grievance committee would liaison with the blocks and the LEC and with some outside ombudsman, possibly from the MLG.

Technical assistance and training would be provided to the community and to LEC in leadership, management, account keeping, electricity consumption, safety, and other matters. USAID has agreed to arrange specific training courses at no cost to LEC. Also, community organizers would be assigned full-time responsibility in conjunction with the IBRD Urban Upgrading Project to be carried out by a new City Department.

The LEC would also assign someone at least half-time to supervise the project. The Public Relations Director would be ideal for this assignment. Peace Corps volunteers may also be suitable.

The experiment would be monitored and evaluated over a period of a year or so. When appropriate it would be gradually expanded in groups of about 10 blocks. Evaluation and performance objectives would be developed in detail on ensuing missions.

An alternative scheme employing current-limiting devices and flat rates is also considered worthwhile, but first more research needs to be done to solve problems of potential by-passing of current-limiting devices and to search for a simple, inexpensive, time-delay circuit breaker with automatic reset.

The cost of the block metering scheme covering all direct costs for all 800 households in Claratown would be on the order of $25,000. However, it is estimated that less than 25% of the households in Claratown could be brought into the pilot project in 1981.

Peronnel training and community participation could begin as early as April 1981. Technical studies (tariff changes, current limiting devices, and detailed design) could begin immediately.

Terms of reference for ensuing consultant missions would include, but not necessarily be confined to, helping finalize technical design of block metering and the current-limiting devices, assisting in the community organizational aspects of the work, helping to coordinate training and technical assistance, and designing an evaluation and monitoring program.

Introduction

This report is based on a visit to Monrovia and interviews with World Bank officials in Washington during the period February 17-March 6, 1981. The terms of reference for this work and persons interviewed appear as Appendices 1 and 2. Briefly, the terms of reference call for the design of a pilot project to experiment with alternative means of supplying electricity service to the urban poor as provided for in the IBRD Fourth Power Loan of 1978. However, in accordance with the findings of the recent (January, 1981) World Bank Study (Liberia: Monrovia Water, Power, and Urban Projects. Analysis and Strategies for Improved Access to Services by the Urban Poor)* electricity service cannot merely be extended to low-income households along the lines of conventional service. Past practices are unsatisfactory from nearly everyone's standpoint. The LEC cannot collect on its bills; the customers do not get service they have a right to expect. Especially for the poor (those households, some 60% to 70% of the city, earning less than $281 per capita per annum**) electricity is not affordable. In short, the conventional system of relying on marketing principles for the delivery and sales of electricity have broken down.

Objectives

This report describes several alternative experiments by which technical, administrative and most importantly, social controls can be

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*Referred to hereafter as the IBRD report on the urban poor or poverty report.

**Or about $164 per household per month.

tested as means to complement and improve the conventional system. Thus, the objectives of the proposals outlined below cover a wide scope. A primary objective is deliver "life-line" (or minimum) electrical service to low-income areas at the lowest possible cost to both the customer and the LEC. Two further interlocking aims are to propose and test controls over energy consumption and to improve the quality of service by simplifying administrative practices. Finally, the proposals described below should be readily applicable to wider areas of the city. Indeed an important criterion of the proposed experiments is that they are replicable and will help solve some of the wider operational problems of delivering electrical service in Monrovia.

Strategy

The premise of extending service to the Urban Poor is that they as customers will be willing to regularly honor their obligation to pay their electric bills in exchange for better service and less expensive electricity. This proposition is not trivial; under the present system it is feasible and cheap to steal electricity. The customary prohibitions against theft--administrative and legal sanctions, social censure--have been rendered ineffective by a system of service which is unreliable and expensive. Many local observors report that cheating is favored because of social pressure against informing, or because of a lack of incentive to "turn in" cheaters. So key parts of the strategy are for the LEC and a target low-income area start with a "clean slate," adopt modified rules, including incentives to counter the problem of illegal connections and profligate energy use.

Proposed Tariff Reduction

A reduction in the barriers to legal electricity service is the most important ingredient in this strategy. Low-income households simply cannot afford even modest service at present rates. The IBRD report on the urban poor discloses that electricity bills for many low-income households run to 20% and higher of their incomes. For households whose priority expenses are for food, shelter, water and clothing (which together can account for 90% of their income) paying for electricity is expendable. To be sure under normal circumstances, conserving on use of electricity should be the first recourse. But for reasons already discussed, it is easier to cheat. Cheaper rates are a first step in solving this problem.

A variety of arguments are presented below in support of adjusting the tariff structure--at least for this pilot project--so that it is more progressive, reflects some of the administrative savings and technical efficiencies incorporated in the proposed schemes, and so that a minor subsidy to introduced as a matter of social interest. A credible case can be made to reduce tariff charges substantially below the present rate for 400 KWH or less. Deposits and connection fees will be lower per capita and therefore also reduced as barriers to service.

The first rationale for reducing the tariff is that the high cost of generating electricity should be charged to the heaviest users. The present tariff does not serve to encourage efficiency in energy consumption. The regressive structure of the tariff encourages (or at least does not discourage) heavy use. This is especially dramatic during peak load periods when gas turbines are pressed into service. I have available no demand studies by which to gauge elasticity of demand for power. But one may suppose that elasticities are lower for households than for commerce and industry where the use of power is needed to earn income. Therefore a marginal increase in tariff for heavier users could be more than offset by a marginal decrease in the tariff for lowest (less than 400 KWH) users.

A further rationale for tariff reduction at least for the pilot project is that administrative overhead costs will be reduced because bill collections and metering are achieved on a block basis. These practices could amount nominally to 10% of customary levels, although in practice--because lower meter reading and accounting costs will be offset by higher personnel costs in community relations--let us assume a 70% savings in billing, accounting, and administration and maintenance. Using the 1980 Expenditure schedules as a gauge, this would reduce the present tariff by 4%.

It is anticipated in the best of outcomes that electricity losses through illegal connections will be reduced. On a citywide basis, losses presently amount to 30% of generated electricity. A reduction of this loss by half could also then be passed on to consumers who save.

Thus, not counting any possible progressive changes in the tariff structure, nor any social interest subsidy, tariff rates for the lowest income households could amount to 19%, as tabulated below:

Possible Tariff Changes

Rationale for Reduction

Progressive rates	?
Administrative savings	4%
Reduction of losses	15%
Subsidy	?
TOTAL	19%

A hypothetical tariff (again, for under 400 KWH) would be .116¢ including FAC. This rate applied to average levels of consumption (say, 250 KWH) reported in the IBRD study of the urban poor would still result in a monthly bill of nearly $29 (a savings of $7), but still some 18% of poverty level income, approximately three times the level suggested by the IBRD Report. It is suggested that this gap be closed by a combination of further reductions (based on progressive tariff and subsidy) and a reduction in levels of consumption by low-income households. This voluntary reduction then becomes an important performance standard for this pilot project and will also therefore be central in community education programs.

Proposals

Two alternatives, A and B, are described below. Both aim to improve service, simplify administration and maintenance, reduce costs, and control consumption. In this last respect, the control of consumption, the two schemes differ. Plan A relies on social controls, Plan B on technical ones.

For both plans, a locale would be selected from the priority category list in the IBRD poverty report (p. 32). The locale should be clearly bounded, small (about 1,000 households), and display some elements of neighborhood cohesion and self-organization. This is critical because community residents must play a role in limiting consumption, safeguarding equipment, collecting revenues, and cooperating generally with LEC.

Claratown (Fanima/Kru/Grebo in the IBRD report on the urban poor) and Slipway are two communities which fit these criteria. Resident leaders of Claratown have been consulted in detail on the following ideas and have expressed, in principle, support for and willingness to cooperate in the pilot project.

Plan A

Under this plan, the community would organize itself into small clusters or blocks of, say, 10* households and electricity service would be metered by the block. Community organizational aspects will be discussed in detail later. Briefly, the present service would be mapped

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*Meaning for Claratown 5 or so buildings. Fewer block numbers require more meters; more are harder to organize.

roughly for the first two or three blocks by LEC personnel with community assistance. Residents would be offered a choice of new conventional service, or retaining their good standing, or if none is established, of joining the block system. Households presently with meters who wish to join the block service would be credited for the return of their meter and deposit fees. It is assumed that most or all households would join the block system. Electricity will be cheaper and deposits and fees lower due to facility sharing.

Block meters (single phase) would be placed at, say, eight feet on "neutral" poles (as opposed to someone's house) and enclosed in a simple metal lock box for protection. If necessary, current transformers would be placed further up on the same poles. Service wires (triplex) to individual households would radiate from above the meter (to minimize mischief). For illustrative purposes, all of Claratown would require some 80 meters. More detailed cost estimates appear in the Estimated Budget.

The chief advantages of this plan are that it reduces extensive metering and administrative costs, eliminates sources of error, and puts a large share of the burden upon the community for collection of amounts due. However, the active promotion and organizing of the community is a sine qua non to success in this plan.

The community through block committees would be responsible for all electricity consumed on their meter. It is therefore in their interest to guard against theft of electricity by reporting or preventing new "illegal" connections. For this reason blocks should be organized to take advantage of kin and tribal ties and physical propinquity. There roughly for the first two or three blocks by LEC personnel with community assistance. Residents would be offered a choice of new conventional service, or retaining their good standing, or if none is established, of joining the block system. Households presently with meters who wish to join the block service would be credited for the return of their meter and deposit fees. It is assumed that most or all households would join the block system. Electricity will be cheaper and deposits and fees lower due to facility sharing.

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The community through block committees would be responsible for all electricity consumed on their meter. It is therefore in their interest to guard against theft of electricity by reporting or preventing new "illegal" connections. For this reason blocks should be organized to take advantage of kin and tribal ties and physical propinquity. There is no guarantee that this form of social control will succeed. The only analogous experience to date is in water projects. A recent IBRD report* urges strongly community participation in the design and implementation of community utilities.

> The social case studies suggest that local committees are capable of assuming a wide range of responsibilities when given proper authority and guidance, including providing liaison between the agency and the community organizing and maintaining records of the voluntary labor force, selecting community members to be trained in facility maintenance, collecting the maintenance fee, keeping accounting ledgers, and filing periodic reports to the responsible authority concerning the results of these activities. (Kalbermatten, 1980:23)

Plan B

This plan would follow the same mapping procedure and offering of options as in Plan A, but would utilize current-limiting devices and flat rate payments instead of fluctuating payments according to block meters. Under this plan each household wishing to join the plan would be fitted with a slow fuse (say, 10, 15, 20 amps) either enclosed in a protective sleeve and designed so only LEC could replace or reset them, or open to replacement by residents who could purchase replacements at the LEC upon proof that their account is in good standing. Delayed reset circuit breakers would be a superior option, but no technical data is available.

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*Kalbermatten, J. et al. 1980. "Appropriate Technology for Water Supply and Sanitation. A Summary of Technical and Economic Options." Washington, D.C.: IBRD.

Analysis and Conclusions: Begin with Plan A

For technical reasons discussed below, I recommend beginning with Plan A. Although Plan B would avoid the expense of meter installation and reduce efforts of community organizing, many observors feel that current limiting devices, though cheap, are too easily by-passed without expenseive protective equipment. Supposing even that the by-pass problem were solved, the use of current-limiting devices would run a good chance of drawing heavily on scarce LEC service personnel for resetting or replacing blown fuses. Automated reset after a time delay would solve this problem.

A further consequence of these technical problems is that Plan B suffers the advantage of having no effective sanction against non-payment of bills. If households can by-pass current-limiting devices, they can also illegally restore power cut by LEC. Plan A relies upon the pressure of social censure and controls in cases where bills are not paid. A block of households can decide to temporarily subvent households unable to pay. If it is decided that block subsidy is untenable, block residents, committee members, and possibly others in the community are in the best position to guard against illegal reconnection of power. Of course in the extreme case there is no solution to massive nonpayment of bills other than to revert to standard practices.

Thus, for organizational, technical, and financial reasons, I conclude Plan A is preferable and that steps should be taken to carry it out. Plan B may prove to be equally good or superior, but in my judgment, more work should be done to investigate technologies for limiting current and for preventing by-pass before experimenting with this option.

Information should be solicited from the World Bank and elsewhere. One alternative would be to offer a design prize at the University for engineering solutions to these technical problems.

The balance of this report confines itself to considerations for carrying out block metering assuming that improvements in Plan B will be sought in the meantime.

Community Organization and Administration

Promoting this project within the community and eliciting cooperation from residents will be a formidable task to undertake; even more difficult will be to sustain a level of commitment after the project is underway. As mentioned briefly earlier, the residents of, say, the first 10 groups of blocks, will be required to organize themselves into blocks, to elect block committee people, to survey the households in their blocks to determine formulae for equitably sharing electricity bills (see Appendix 5), to help educate residents about electricity use, and to organize a single smooth supervisory committee representing the blocks and community leadership. The most difficult responsibility of course lies in the month-to-month collection of revenues and settling of disputes. Some system of financial or service incentives should be considered to compensate block committee people. This is an item for further study in the following mission.

I have recommended Claratown as a pilot area for this experiment precisely because it demonstrates ample evidence of self-organizational abilities. (See Appendix 3.) The town is organized along tribal lines (mainly Fanima and Kru and Grebo) and there groups have coalesced around the common struggle to gain title to their land. They have self-imposed taxes to hire a lawyer, have regulated new housing construction internally, and have observed a rough street layout pattern.

These efforts will be supported and strengthened by the World Bank Upgrading Project to be carried out by a soon-to-be-created Department of Project Development in the MCC. Community organizing personnel will be trained and possibly take up residence in Claratown.

Parallel but more extensive organizing efforts will be required for this pilot project. Authorities in the city (Deputy Mayor Striker), the Ministry of Local Government (Vice Ministers Johnson and Dunbar) and the World Bank (Haldane and Meijer) are supportive of integrating one or two additional community development workers (i.e., community organizers) into the Urban Upgrading Team to coordinate the pilot connection project with other upgrading activities. Though details could be worked out later, it would seem logical for the LEC to write the work program, help pay salaries of a community worker(s) and serve as supervisors over their work even though on a day to day basis the workers would be part of the city team.

A complementary or possibly alternative option would be to accept an offer by the U.S. Peace Corps to assign two community organizers to Claratown. No objection has been raised against this idea.* The Deputy Mayor is pleased with the work on an urban water well program currently being carried out by PCVs in conjunction with the city. Besides the advantage of no monetary cost to LEC, PCVs could represent an element of neutrality in the sensitive area of money handling and revenue collection. The chief disadvantage--really more an uncertainty--is whether young white PCVs would be as effective in mobilizing the community as trained Liberians might be.

The LEC (Public Relations Department, perhaps) would also play an important role in "backstopping" the organizing effort with technical

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*Although at least one official noted that Peace Corps has not come through on its promises in the past.

information and assistance concerning the cost and technology of electricity service. LEC representatives could help to educate the community on electricity costs and on the need to reduce average consumption. Technicians could also offer assistance (in evening seminars, perhaps) on improving household wiring and reducing hazards of fire and shock. These educational activities could also be detailed further in the following missions.*

Service Delivery and Billing

Considerations of technical design of electrical service will not be taken up here. The general principles of the service system were described earlier. The pilot project differs from others in that meters would be registered under names of block committees (like businesses) or the overall supervisory committee, or, if need be for legal reasons, under individual names of block committee representatives (although this arrangement would certainly deter candidates from coming forward).

Each month, LEC meter readers with community relations training would read block meters (possibly in the presence of committee representatives) and calculate and issue a bill immediately. Blocks could either have collected in advance, making collections on estimated costs so as to make a payment on the spot, or circulate immediately to collect amounts due in proportions from each resident. A third possibility would be to collect payments over the following weeks (receipts given in all cases) for payment to LEC the succeeding month. The payment system would have to be worked out by blocks and LEC.

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*See the section on training.

Enforcement

Nonpayment of bills by individual block residents would of course then be a problem of the block as a whole. Blocks could decide either to subsidize needy households or to request LEC cut off service. But it would be the block's responsibility, backed up by the Supervisory Committee and other community leaders, to keep disconnections in force, just as it is their responsibility to prevent new illegal tapping into power lines or to sanction new ones. Neighboring residents are in the best position to carry out this responsibility. In the same way, blocks have an incentive to guard against excessive use of electricity because everyone's bill goes up. Naturally, in these matters block committees can make up their own rules as long as the bills are paid. Naturally, there is little recourse to disconnection for wholesale failure in a block to pay, unless the supervisory committee for some reason would want to bail them out.

Institutional Arrangements

A number of institutions will be involved in one way or another in this pilot project and so it is imperative that an LEC Special Projects team (consisting, say, of one person from each Planning, Commercial, and Public Relations) oversee the work by a fulltime community oriented LEC professional (possibly Khasu in the initial stages. Later, as the work expands, a new person(s) could be hired, or a PCV(s) assigned under Khasu) all reporting to the Deputy Managing Director.

The community workers would need to be in regular contact with LEC and the DPD to carry out their main assignment and to coordinate it with DPD activities and timetables. Thus the LEC special project team and the DPD should probably have at least regular briefings.

One subject of possible confusion in the minds of residents is the public street lighting planned as a part of the urban upgrading project. Care must be taken to distinguish this program component--in terms of costs--from the pilot project and monthly electric bills.

Training and Technical Assistance

Because of the extensive community involvement in this project, training, and technical assistance are essential elements for project success. Fortunately, a USAID-sponsored training program is being organized and appears to be available to fill many of the training needs of this project. The following table outlines a suggested training curriculum.

Training Activities for Pilot Project

Training Curriculum	Trainees affiliation (and # of persons)	Trainers	Course Time
a. Leadership seminar	Community Residents, LEC community workers (5-10)	USAID	2-4 weeks (repeatable)
b. Accounting and bookkeeping	Block committee representatives (6)	USAID	2-4 weeks (repeatable)
c. Community organizing	LEC community organizer(s) (1-2) with Urban Upgrading Team(3) and Block Committee Members (4-6)	USAID	2-4 weeks (repeatable)
d. Community Relations	LEC Personnel (3-6)	USAID	3-4 sessions
e. Electricity use in households	Community Blocks (10-20 persons)	LEC	1-2 sessions
f. Wiring and safety	Community Block Groups (10-20 persons)	LEC	1-2 sessions

a. Leadership Seminars. Short sessions designed to enhance the natural skills of recognized leaders in the community (tribal chiefs, religious leaders, elected "officials", etc.). The seminars should be oriented to fit the objectives of the pilot project in particular, and the urban upgrading activities generally. Skills would include problem solving, dispute resolution, communicating, and techniques of mobilizing community participation. USAID would arrange the seminars of perhaps 4-8 sessions.

b. Accounting and Bookkeeping. Basic techniques for keeping records of payments and amounts due, handling money, receipts, etc. This course would be designed for bock committee representatives responsible for allocating electricity bills and keeping track of (or collecting) amounts due from each household. USAID would arrange the seminars in 4-8 sessions.

c. Community Organizing. Techniques of working with local residents on self-help activities. Topics would include identifying felt needs, mobilizing resident participation, communication skills, survey techniques, starting and running meetings, etc. This course would be aimed primarily at City and LEC workers and selected community residents interested in organizing block committees for the pilot project. It is anticipated this course would be organized for the urban upgrading project. USAID would arrange the course in 4-8 sessions.

d. Community Relations. Basic skills in dealing with low-income residents unfamiliar with (and possibly suspicious of) LEC. The course could possibly make use of community residents skilled in articulating the feelings of their neighbors toward large, impersonal institutions such as the LEC. The course would be attended by the LEC personnel in

Public Relations, Planning, and Commercial Departments and meter readers who will be participating in the pilot project. USAID would arrange; 3-4 sessions.

e. Electricity Use in Households. Basic information on generation and distribution of electricity, LEC operations, measuring flows consumed by household appliances, calculation of costs, need for conservation, etc. The course would be aimed at residents in blocks and would be intended to deepen understanding of consumers of electricity use and to encourage conservation. Course would be arranged by LEC and conducted in one or two sessions.

f. Wiring and Safety. Technical information of flow of current in households. Topics would include concepts of voltage, amperage, watts; wiring size and safety, need for grounding, couplings, balancing load, hazards to children, avoiding and fighting electrical fires. The course would be aimed at blocks of community residents and would be arranged by LEC and offered in one or two sessions.

Monitoring and Evaluation

In order to gauge the program of the pilot project and to increase its effectiveness, a program should be outlined by which the present system of electricity service may be compared against the changes to be introduced in the pilot project. Monitoring refers to tracking the tasks outlined below against a pre-set timetable. Adjustments in the project can be made as experience is gained. While the monitoring effort would be more or less continuous, an evaluation of performance would take place periodically (e.g., every three months in addition to irregular reports as warranted).

Evaluation requires two further tasks. First is to identify performance standards or goals of the project against which degrees of success or failure are to be measured. Second is to generate baseline data describing the present state of affairs in terms of these goals.

Although it is slightly premature to lay down performance standards, it is possible to identify broadly the areas where progress is to be expected and to suggest indicators to measure success or failure of the pilot project. The first objective is to connect several hundred households by the end of 1981. Without having discussed this with low-income residents, this objective is somewhat a shot in the dark. But strictly from a standpoint of LEC logistics, this number should be achievable. A second goals (and all further goals pertain to the pilot project area only) is to reduce the incidence of illegal theft by an appreciable degree. Present numbers of illegal connections in a given area can be estimated from the block map sketching exercise. Third is to increase revenue payments* by a proportion similar to the decrease in illegal connections. Fourth, the project should aim in the long run to reduce per capita consumption of electricity by at least 25% on the assumption that a policy will be adopted to combine tariff reductions with cutbacks in energy consumption in order to make the average cost of electricity equal to about 5-6% of average income. A reduction in consumption by 5-10% by the end of 1981 appears reasonable. A fifth goal is to reduce service calls for vandalism, fire, and health hazards.

More detailed performance standards may be further developed during the next consultant visit, along with the monitoring and evaluation program.

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*But not total revenues. Present levels of payments may be obtained from customer payment records.

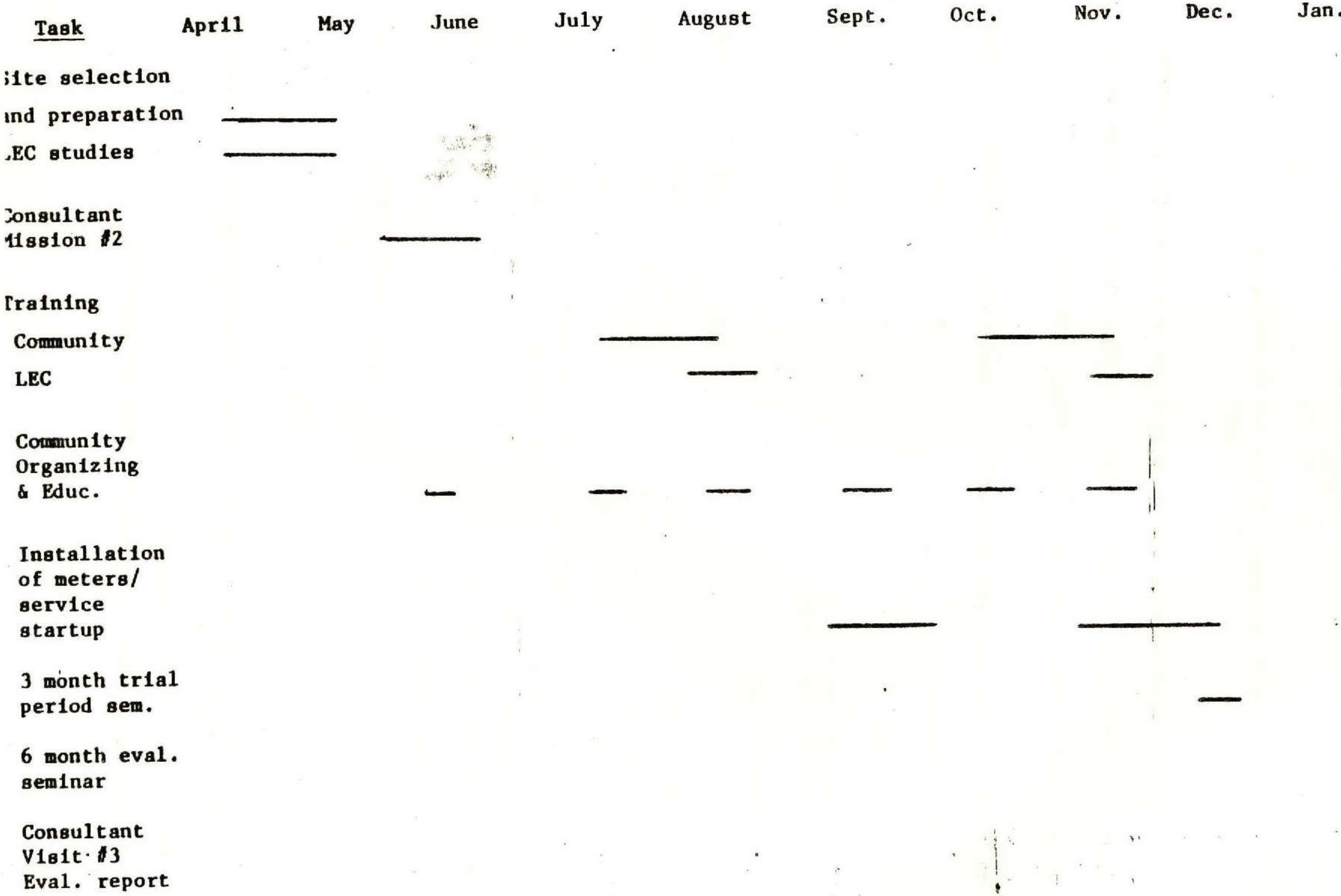
Work Program and Timetable

TIMETABLE ELEMENTS

1. Site selection and preparation
    a. tariff change studies
    b. sketch block map
    c. complete technical design
    d. community education (special LEC team)
2. Next visit consultant (#2)
3. Training
    a. Leadership training (LEC team and community)
    b. Accounting and bookkeeping (community)
    c. Community organizing (LEC and community)
    d. Community relations (LEC)
    e. Electricity use in households (community)
    f. Wiring and safety
4. Community organizing
    a. Division of blocks
    b. Election of leaders and committees
    c. Consultation with LEC (working relationships)
5. Installation of meters and start up
    a. Negotiation with community blocks
    b. Hook ups
6. Three month trial period seminar
7. Six month evaluation seminar
8. Consultation visit (#3) and evaluation report

Timetable (Estimates)

Timetable (est.) 1981



Budget
(est.) 1981

800 Low-Income Household Connections
Pilot Project

These esimates cover labor, materials, and nonordinary expenses (e.g. community meeting and training). Budget does not cover tariff studies nor research on time-delay circuit breakers.

TASK (from work plan and timetable)		MAN WEEKS	RATE/WEEK	TOTAL
1. Site Preparation		3	150	450
3. Training*		—	—	—
4. Community Relations (1 person half time)		13	100	1300
5. Installation				
Labor		16	100	1600
Materials	No.		Rate	
Meters	80		36	2880
CTS**	80		65	5200
Cable (#12 & #14)		3 coils each	300	1800
Triplex #2		≈ 2,000 ft.	$1.70/ft.	3400
Transportation		20 days	$50/day	1000
6. Trial Period Seminar				1500
7. Six Month Evaluation				1500
		TOTAL DIRECT COST		20,630

*The training can be covered in USAID Training Program scheduled to begin this year

**May prove to be unnecessary.

***Assume about half of present wiring is suitable.

Next Steps

The following list covers actions or decisions to be taken in the immediate future:

1. Policy decision to launch Plan A.
2. Begin study of effects of tariff reduction (demand elasticities, possible subsidies, special "life-line" rates).
3. Designate pilot project special team (from Planning, Commercial and Public Relations Departments).
4. Contact MUDP and MLG for informal discussions to coordinate with urban upgrading and to make intentions known to Claratown.
5. Block sketch map service in Claratown.
6. Coordinate with MLG (Johnson, Dunbar) and MCC (Striker) to hire community organizer or PCV.
7. Explore possible use of PCV with Peace Corps (Harrington).
8. Discuss training needs and resources available at USAID (Benson).
9. Draw up specifications and solicit entries in design competition for low-cost, time delay circuit breaker with automatic reset that can be protected from by-pass and can be produced locally.
10. Campbell will follow up to get experience from IBRD.

APPENDIX 1

Terms of Reference

The terms of reference for this work, as suggested in February 13, 1981, telex to LEC from Mr. B. M. Thiam of the IBRD, cover the following points:

- o Present and discuss the above report for improved access of services by the Urban Poor to elicit LEC reaction and decisions and to define programs and strategies of action.
- o Review detailed proposals with LEC regarding organizational, logistical, legal or any other problems that could impede implementation of recommended strategies.
- o Assist in defining a detailed implementation program, manpower, and budget requirements.
- o Assist in locating an appropriate community-based organization, agency or agencies to work with LEC in carrying out service and cost-recovery programs.
- o Work with such agency/agencies to establish the basis and means for on-going cooperation.
- o Terms of reference for subsequent missions will be defined during the initial mission.

APPENDIX 2

List of Persons Contacted

1. Claratown

   Davis, Seabo, Yulorboh, Kromah, Keede, Dulay, Sonce

2. IBRD

   Meijer, Haldane, Courtney, Gilling, Posada, Liberatori, Hussain, Trede

3. LBDI

   Vinton, Titus

4. LEC

   Yuan, Macauley, Bhat, Vawar, Tubman, Quist, Yhap, Kawah, Mayah, Darwin, Bhalerao, Nagbe, Elliot, Stubblefield, Quitee, Khasu, Paddy

5. MCC

   Striker

6. MLG

   Johnson, Dunbar

7. MUDP

   Skinner, Da Thong, Wuo

8. Peace Corps

   Harrington, Bell

9. University of Liberia

   Woodtor

10. USAID

    Benson

APPENDIX 3 and 4

The following descriptions were taken from the MUDP Task Force Report on proposals for the World Bank Urban Upgrading Project.

APPENDIX 5

Sample Guide for Allocating Block Charges to Households

Estimated KWH and Costs of Using Household Electric Appliances

Appliance	Rated Watts	K.W.	Estimated KWH/day/mo.	x .15$
1 Bulb	50	.05 x	8 x 30 = 12	$1.80
			4 x 30 = 6	.90
4 Bulbs	50		8	7.20
Table fan	15	.015 x	3 x 30 = 3.6	.54
Electric Iron	1,100	1.1 x	1 x 30 = 33	4.95
Hot Plate	150	.15 x	2 x 30 = 9	1.35
Refrigerator Office type	300	.3 x	14 x 30 = 126	18.90
Hot Water Heater	1,200	1.2 x	2 x 30 = 72	10.80
Radio	10	.01 x	4 x 30 = 1.2	.18

APPENDIX 6

Abbreviations Used

DPD	Development Projects Department
FAC	Fuel Adjustment Charge
IBRD	International Bank for Reconstruction and Development
KWH	Kilowatt hours
LBDI	Liberian Bank for Development and Investment
LEC	Liberian Electricity Corporation
MCC	Monrovia City Corporation
MLG	Ministry of Local Government
MUDP	Monrovia Urban Development Project
PCVs	Peace Corps Volunteers
USAID	United States Agency for International Development

APPENDIX 7

Suggested Terms of Reference
(Consultant Visit # 2)

Generally speaking, the mission should continue work begun in the first mission taking into account any modifications in the proposal for the pilot project. A number of specific items will require further work.

- o Help brief and train the Special Projects Team and iron out working relationships with other insitituions to be working in the project site.
- o Help detail and coordinate training programs to be carried out by USAID
- o Assist in explaining the pilot project to residents of the site.
- o Explore alternative procedures for payment of monthly bills (actual transfer of cash from committees or residents to LEC)
- o Explore possible alternative incentives to or rewards for residents to serve on block committees
- o Collaborate on tariff studies for charging minimal amounts to low-income residents for "life-line" electricity service.
- o Continue research on current-limiting devices and investigate possible sites to implement Plan B.

PUR - General — Doc.
PcI - General — Doc.

BUILDING SECTOR COST DATA REVIEW

prepared for

URBAN DEVELOPMENT DEPARTMENT

THE WORLD BANK

by: ALASTAIR G. LAW (Cons.)

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September 1981

TABLE OF CONTENTS

SUMMARY

1. The prime objective of the study is to help provide the Urban Development Department with a better system to collect and analyze building cost data as a basis of improved project appraisal. There have been several projects where the divergence between estimates of construction costs at appraisal stage and the actual costs incurred has been excessive with a resultant lack of credibility in project cost estimating.

2. It is recommended that steps be taken to develop a cost management system within which borrowing countries would be required to submit cost data in a standardized form; have it updated at regular intervals, and which will be used within the Department for comparative analysis. In addition, the data collected will form the basis of a cost data bank within the Department and provide a facility for regional cost comparison as needed.

3. The first step in the creation of this system involves three sets of forms which have been prepared for use in the field. It is important to note that the filling out of these forms is to help improve the degree of the cost analysis. Also through the systematic approach highlight potential faults in the base costs.

FORM A - Construction Industry Data File

4. The objective is to have this data collected at the beginning of the project cycle. It includes basic construction industry data and should be the basis of all construction cost estimating. The form contains a section 'Key Indicators' which will form a basis for tracking construction cost escalation. This form should be updated at least twice a year prior to appraisal and should form part of the appraisal reports.

FORM B - Project Cost Data - Infrastructure

5. This is project related and all cost data included is derived from construction cost estimates prepared by the borrowing country. The cost data developed is essentially for comparative purposes and should serve as a "trigger mechanism" for identifying potential problem areas. This form should be updated at each phase of the design process and at coinciding stages of the project preparation cycle, and be finalized at appraisal. It should also be periodically checked during supervision as a basis of monitoring costs.

FORM C - Project Cost Data Summary - Infrastructure

6. This is a cost summary form, with cost data derived from FORM B. It is self-explanatory and should be included in all appraisal reports, in the main body of the text. It should be updated at the same frequency as FORM B, and checked to determine variations in base cost from appraisal on the previous update.

INTRODUCTION

1. This report is the result of a 30 work day study carried out during the period February - June, 1981. The terms of reference are contained in a memorandum from Michael A. Cohen, Acting Chief, URBOR, dated February 20, 1981. The prime objective of the study is to "help provide the Urban Development Department with a better system to more effectively collect and analyze building cost data." In order to make proposals as to the most effective means of fulfilling this objective, the study has focussed upon:

(i) the current perceptions of problem areas in building costs;

(ii) the state of the art in the preparation of cost estimates and budgets;

(iii) a review of the types of building cost data which might be obtained, and the basic measurement rules associated with them;

(iv) the preparation of draft data collection and analysis forms; and

(v) recommendations for implementing an appropriate cost data collection system.

2. The need for this study is based on several projects where there has been a considerable divergence between building costs estimated at appraisal stage and actual costs during, or at the end of, implementation. In some cases these have been as high as 200-300% of the original estimate for the same aspects of the project.

3. There can be many reasons for cost increases, and they can range from inadequate project preparation data (both scope and price), to dramatic increases in countrywide construction cost escalation. However, it is important that a system is developed which will provide a means of identifying potential problem areas, and form a basis for realistic cost evaluation at all stages in

the project cycle. In this respect, it is of importance to recognize that the collection, analysis and storage of construction cost data is only a means to an end. The end is a cost management system which should institute a mandatory system of submittals and approvals, thereby providing an effective control mechanism, in addition to creating a self-generating cost data bank. There are several other benefits from such a system; they are:

(i) a facility for regional and international cost comparison;

(ii) the formation of an "institutional memory" within the Urban Development Department;

(iii) the creation of a working tool for Bank professionals;

(iv) a cost framework for guidance of borrowing countries, to improve their own institutional capabilities in cost management; and

(v) a model created by the Urban Development Department which could be adopted by other Bank Departments and International Agencies. In this respect it should be noted that similar problems in cost management have been identified within at least two U.S. Government agencies, working in developing countries.

REVIEW OF THE CURRENT SITUATION

4. During the period of this study, discussions have been held with individuals representing a broad cross section of projects and interests. In addition, four group meetings were convened at which different aspects of the study were reviewed. Specific field cost data was gathered during missions to the Philippines, India and Kenya in February 1981. In addition, documentation for the following projects has been reviewed to make an evaluation of typical costs data available:

A. Project Reports

- Yemen Arab Republic - Urban Development Project Preappraisal Mission
  Back-to-Office and Full Report - May 7, 1981

- Jordan Urban Project
  Volumes 1, 2, 3, 4 and Final Report
  Halcrow Fox and Associates
  Jouzy & Partners - October 1979

- Lahore Urban Development and Traffic Study
  Final Report, Volumes 2 and 4
  BKM Associates - November 1980

- National Housing Authority
  Republic of the Philippines
  Dagat-Dagatan
  Various reports and studies - 1977-1980

B. Other documents reviewed

- Sites and Services Projects
  Survey and Analysis of Urbanization Standards and On-Site Infrastructures
  IBRD 1974

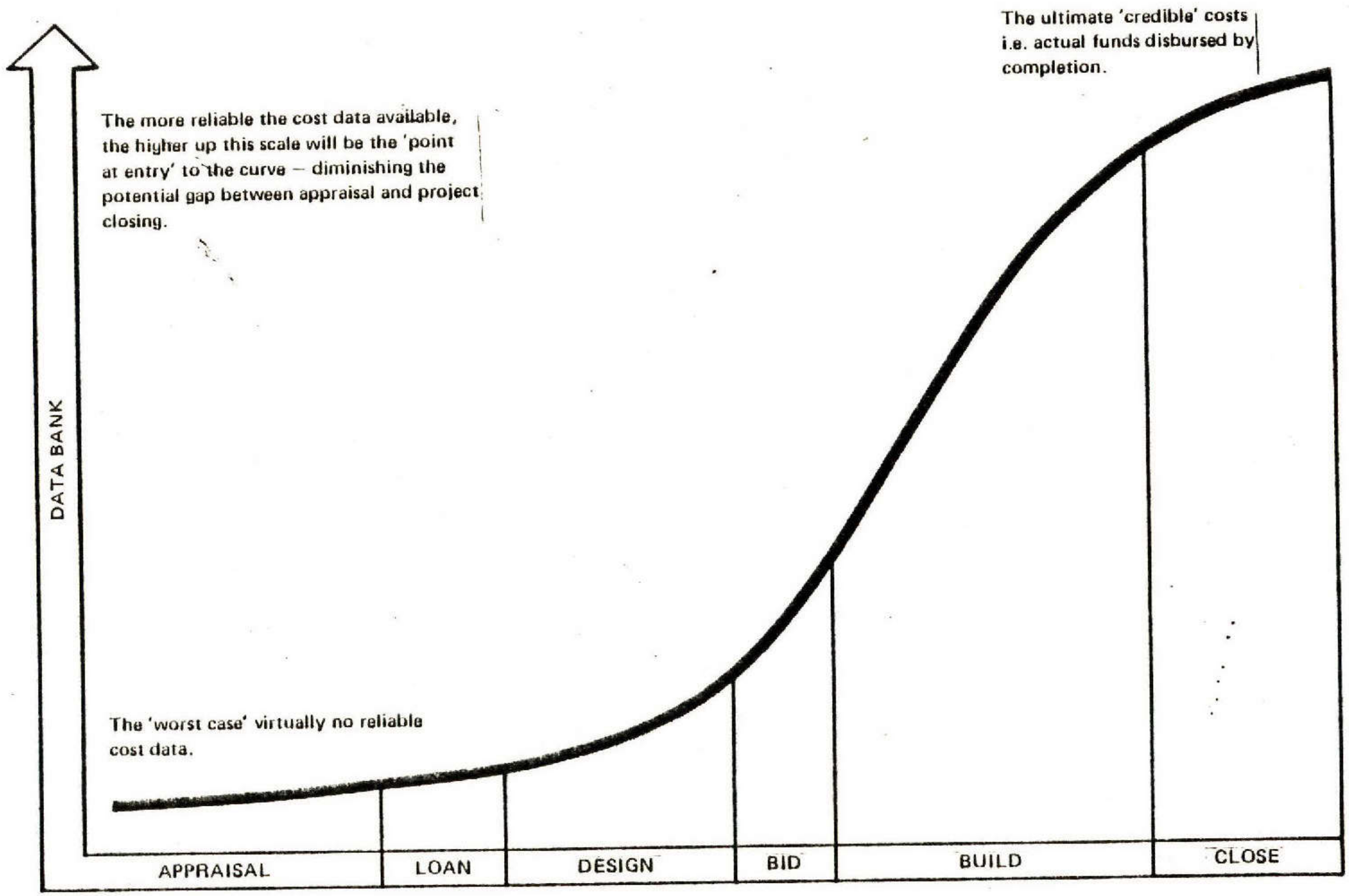
- Urbanization Primer for Design of Site & Services Projects
  World Bank October 1979

- IBRD/PADCO Bertaud Model
  Draft Copy - Undated

PROBLEM AREAS

5. The fundamental problem in cost estimating perceived within the Department is the lack of credibility in long range forecasting (three to five years). Although not unanimously held, the view was expressed by the majority of professionals who attended the various discussion groups throughout the study. The entry point in the 'credibility curve' (see Fig. 1) is largely dependent upon the accuracy of the base data available at the time of project preparation. There is also a need to monitor costs as they occur through the various stages of the project. The use of contingency sums to attempt to reconcile project costs with appraisal estimates needs better control and definition. Large contingency amounts do little to improve credibility of base costs.

FIGURE 1: THE COST CREDIBILITY CURVE



6. In reviewing project reports, real comparison was almost impossible, because of a lack of standardization in the reporting of construction costs. For example, in several cases it was noted that typical costs (e.g. M^2) included such things as land costs and/or supervision costs. If effective cost data is to be collected it is important that a standardized format is used. Such a format is presented in Annex 1.

7. A similar problem exists in terminology. For example, periodically it was stated that costs on a specific project had "escalated" by a certain percentage, meaning that they had increased from the originally projected cost. The word 'escalation' is used within the construction industry specifically related to construction cost escalation related to the passage of time (e.g., increases in wage rates) as opposed to increases brought about by low initial estimates or changes in scope of the project itself. It is important that a clear distinction is made and it is recommended that a standard set of definitions is adopted.

8. Another problem in cost data collection is related to the added burden likely to be placed upon project staff in the field. While it is agreed that additional work should be avoided, two issues are important:

(a) both the review of project documentation, and recent experience in the field, indicate that considerable cost data is readily available;

(b) the borrowing country should be required to submit most of the relevant cost data at various stages throughout the project cycle, both as part of preparation and as part of monitoring and supervision.

If set up effectively, a cost data collection system should not burden Bank staff in the field. The responsibility to prepare the data should be largely that of the borrowing country, or their consultants.

9. Several potential problems regarding types of cost data available have been raised during discussions in the Department. All, in fact, support the need for a consistent, basic cost system. They are briefly summarized below.

(a) Unit prices are not always available.

This is agreed, since their availability tends to follow procurement practices in the specific country. Another inconsistency is the lack of definition of the constituent parts of a unit price (i.e. labor, materials, plant, overhead and profit)

(b) Cost analysis based upon bids can be deceptive.

This is also true. Variation can occur, for example, when Bills of Quantities have included many "provisional sums" (allowances) which, when subsequently measured and valued, substantially increase the building cost. This situation emphasizes the need to analyse the project cost at completion.

(c) There can be considerable discrepancies between Government published costs and market prices.

A typical example is the public sector PWD Schedule of Rates used in India which varies substantially from market prices quoted by the private sector contractors. This highlights the need for cross checking all cost data.

(d) Construction costs can be substantially effected by punitive contract conditions.

In a project case cited at one of the group meetings, it was noted that a 200% cost increase was directly caused by financial conditions imposed within the contract conditions. This emphasizes the relationship between cost data collection and cost management. The cost management review process may necessarily include contract documentation.

10. It is considered that most, if not all, of the problems would be overcome by a properly structured, well managed cost system. The involvement of the borrowing country in the collection and provision of standardized, pro-forma data will be of prime importance.

PREPARATION OF COST ESTIMATES AND BUDGETS. - CURRENT PRACTICES

11. There are many variations in the methods used to develop construction cost estimates for project appraisal purposes. Much of the basic cost information is supplied by the borrowing country via the appropriate government agency, with or without the help of consultants.

12. Where projects have been fully designed and costed, the data can be incorporated into appraisal reports with only minor adjustment. However, in cases where only preliminary designs have been completed, or substantial changes may be recommended before Bank approval, then considerable reliance must be placed upon a combination of existing data, judgement and individual experience of Bank staff.

13. In this case, all the perceived problems come into play and the estimates prepared substantially reflect a combination of the problems discussed in the last section of the report.

14. From the standpoint of methodology for preparing cost estimates, the essential prerequisites to improve the state-of-the-art are, standardization of format; consistency in approach; and an ability to cross check all data. At this time, none of these three requirements are apparent.

TYPES OF COST DATA AVAILABLE.

15. Construction cost data may be obtained from an extremely wide variety of sources. These will range from detailed labor and material prices which may be obtained from within the industry itself ("raw data") to reports in the media of construction projects and their cost (e.g. an announcement that a 200 place school was planned at a specific cost. This immediately provides a functional cost per student). In fact, the wealth of construction cost data available presents more of a problem than the lack of it, since to be of value it is essential that the data is researched, analysed and synthesized in a consistent manner, and retained for historical purposes.

16. The nature and availability of cost data in three countries was investigated during a February, 1981 mission to the Philippines, Kenya and India. The cost data collection document was intentionally comprehensive so that we could test both the availability of data and the willingness of those persons contacted to complete it. In addition, and by way of additional investigations on the same topic, the document was also circulated for comment within the Department.

17. The results of this survey were particularly valuable in the development of the proposed data collection system. The three country overview provided an insight into the types of data normally available; the amount of effort required to collect comprehensive cost data, and the level of mutual concern demonstrated at national and project level.

18. A review of the three country cost survey produced the following highlights:

(i) The Philippines.

The Dagat-Dagatan project unit provided a substantial amount of data, in the format requested and in the reasonably short time available. This included basic material prices and labor rates, as well as unit prices. In addition, a considerable amount of project cost data was collected. A detailed examination of these project costs was carried out, but a general observation would be that there were several apparent inconsistencies, which make it difficult to relate the various costs with one-another. However, this was primarily a function of the presentation format. What was important was the availability of the data and the willingness to produce it.

(ii) Kenya.

The data collection document was not completed. However, project cost data was made available and a willingness to provide the required data was expressed. A most important informational document received, was a publication from the Department of Land Development, University of Nairobi, listing a series of typical construction costs. This very useful data sheet is updated regularly, and could form the basis of a departmental data bank for that country. This unexpected source of cost information, in addition to the project data, supports the view that a structured cost data collection format is realistic.

(iii) India.

The cost data was obtained from the Corporation of Madras. The pro-forma document (cost data collection) was not completed. A typical Schedule of Rates for Road Works was received. Typical tender (bid) documents and Bill of Quantities for both infrastructure and core units, completed the data made available. Only the core unit prices represent project related data, but it is not noted whether these costs are based upon estimates or bids. Although this information is unrelated and unstructured, and, therefore, of little value, it is representative of the type of cost data that might be expected from that country. It does not seem unreasonable, however, to assume that a structured request for information could be fulfilled.

19. As a conclusion to this section, and forming a background to the proposals and recommendations, the following issues should be taken into account:

- the amount of cost information currently being processed in the Department is sufficient evidence alone to support the view that obtaining the type of data required for Departmental purposes is possible.

- borrowing countries should be required to conform to a pattern of submittals, based upon the project cycle; wherein they would provide the Bank key cost data for evaluation and approval before continuing to the next stage.

- in addition to project cost submittals, borrowing countries should provide the Bank with basic industry cost data. This information should be evaluated, updated in the country and checked by Bank staff.

- the process adopted should not place any substantial burden on Bank staff during the process of appraisal, but should provide them with a tool for cost management and control.

- it is important that a series of standard definitions and rules of measurement are established for common use by Urban Departmental staff and borrowing countries. This would be an important task to be completed in the next phase of this study.

PROPOSALS AND RECOMMENDATIONS - PROPOSED METHODOLOGY

20. It has become apparent during this study that the collection and storage of construction cost data, and the intended uses of this data, ("to improve the credibility of cost estimates") are so closely inter-related as to become inseparable. It is, therefore, no longer relevant to proceed solely in terms of a "data collection" system, but to develop, on a trial basis, a cost management system. The close relationship between data can be seen by referring to Figs. 2-8.

21. Fig. 2 **illustrates** how project information can be analysed and synthesized through the cost data bank to provide the basis for budget preparation. It suggests that certain data extracted and retained from projects will be "constants" or, base data, which will become the "givens" on future projects. Each new project, unique in itself, will be adjusted by the variables that exert specific constraints and must be assessed in order to complete a project estimate of cost.

22. Fig. 3 illustrates the process whereby the Department should acquire the data which will be retained in the data bank. This is an important part of the control system, since at each phase (or intermediate phase) of the project cycle, there will be a "trigger mechanism" which will encourage a checking and verification of project data before approval to proceed is permitted.

FIGURE 2: BUDGET PREPARATION FROM DATA BANK INFORMATION

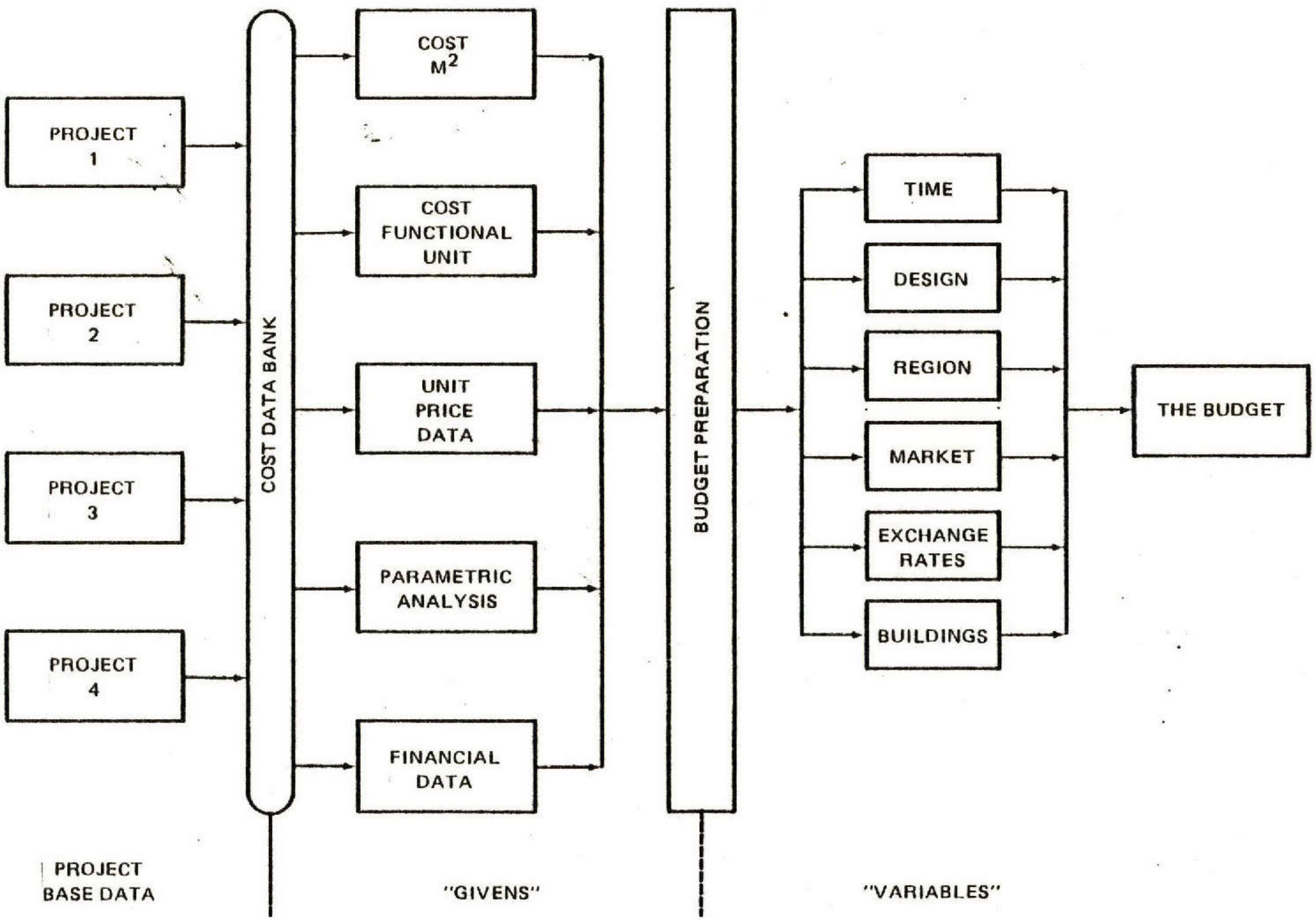
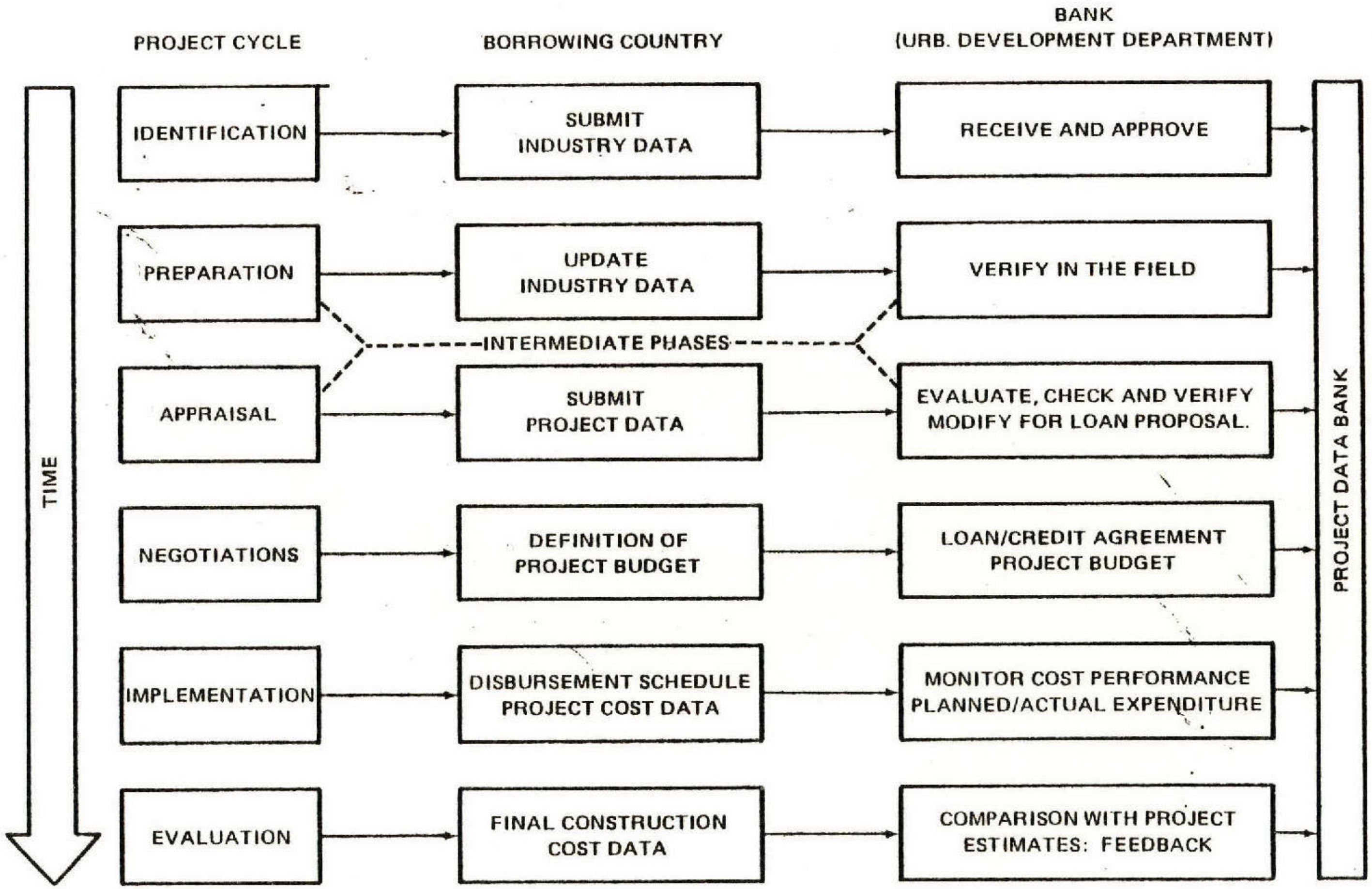


FIGURE 3: PROCESS OF COST DATA ACQUISITION



23. A cost management system must be structured within the framework of the variety of project types in the Urban Sector. The generic system could, for example, be categorized as follows:

(a) SITES AND SERVICES

(INFRASTRUCTURES)

- off site
- on site

(b) SHELTER (ON-PLOT DEVELOPMENT)

- sanitary core
- core and basic rooms
- simple dwellings

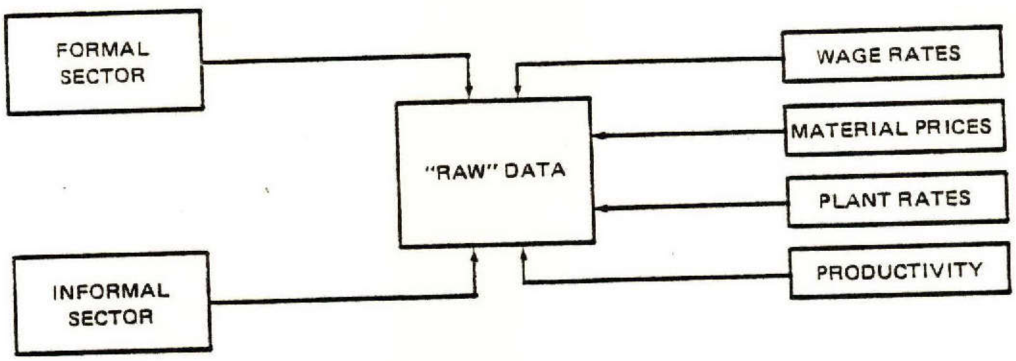
(c) COMMUNITY FACILITIES

- markets
- clinics
- schools
- work shops

Since each of these generic types has its own distinct cost characteristics it will be necessary to develop the cost reporting format accordingly. (See Annex 1)

24. A prequisite to project related data, is what has been described as "industry base data" (see Fig. 4). This is an essential component of the data bank since it provides a baseline from which to calculate many of the 'variables' (e.g. time, regional, etc.) This information should be obtained at a very early stage in the project cycle and be updated at least twice each year, prior to appraisal and during supervision.

FIGURE 4: BASIS FOR INDUSTRY COST DATA



Irrespective of whether construction is carried out in the "formal" organized sector or the "informal" loosely knit sector, the constituent components of construction cost still remain the cost of labor (or its opportunity cost); the price paid for materials and the cost of ownership or leasing whatever plant might be employed. These represent the "raw" construction cost data which will be bound together by the productivity achieved in the field.

25. Project related data will include "unit price data" (see Fig. 5). In this case, it will be imperative to define specification, content and related procurement policy.

26. Cost 'norms', (See Fig. 6) or typical cost relationships, may be developed as components of project cost data. The most important use of these norms will be in comparative evaluation between projects and countries. This data, thus, becomes a significant cost control tool.

27. An adjunct to the development of cost norms, is the identification of 'abnormal' conditions (see Fig. 7). These are the variables in the cost data bank, and experience over a number of projects will be of value in the development of contingency amounts to be included in preliminary estimates during project appraisal.

28. The compilation of cost norms and the costs derived from abnormal conditions should provide sufficient information to develop typical cost standards. These would, in essence, become Departmental base lines and, again form an important part of a cost management system, by way of comparative analysis. Cost models may be developed where appropriate, more typically in building types (see Fig. 8). The model provides a more detailed analysis by building element.

29. The first step in the development of the cost management system, will be the preparation and adoption of standard forms for cost data collection, monitoring, and six monthly updating. Some draft examples have been prepared (see Annexes 1,2 and 3) which should be tested in a project situation, refined and finalized prior to universal use.

FIGURE 5: PROJECT BASE DATA COST

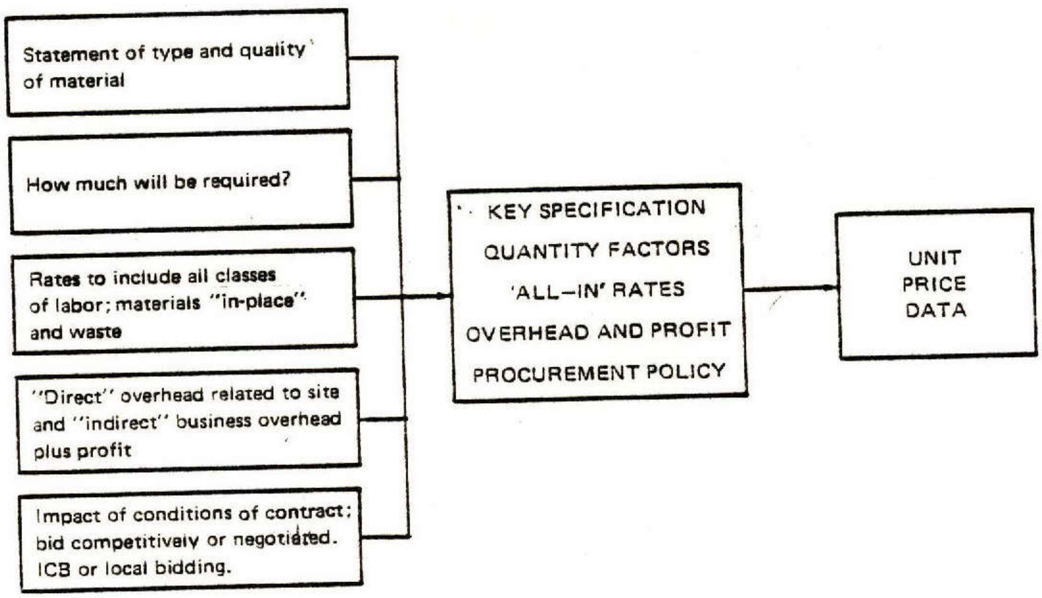
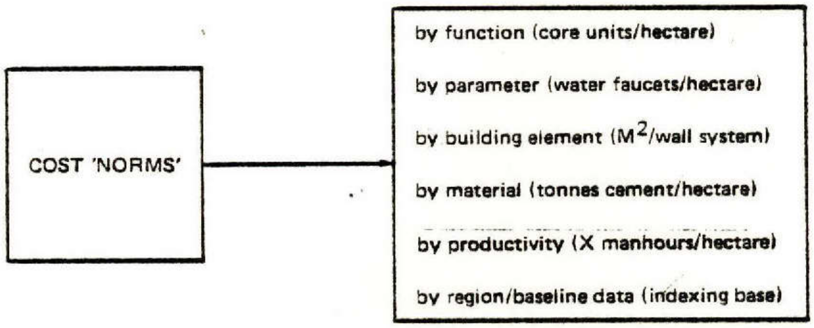
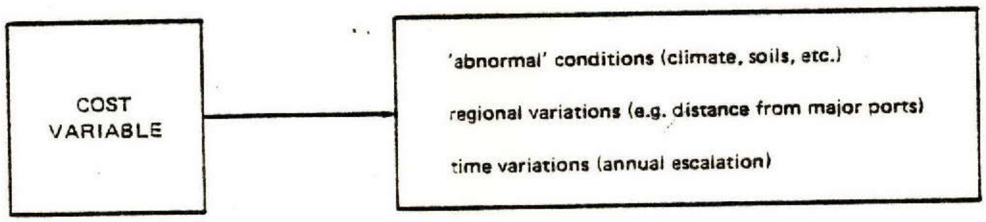


FIGURE 6: PROJECT BASE DATA



For comparison purposes, projects may be analysed into a series of cost 'norms' as shown above. A comprehensive cost management system would provide a sufficient data base for cross referencing and checking project data.

FIGURE 7: PROJECT BASE DATA



TYPICAL COST MODEL FOR CORE HOUSING

FIGURE 8

ELEMENTAL COST MODEL/PLAN

PROJECT:	JORDAN	AREA:	100M^2 (PLOT SIZE)
BUILDING:	CORE UNIT		
DATE PREPARED:	30 APRIL '81		
COST DATA AT:	NOV. 1979	CURRENCY:	Jordanian Dinars (JD)

ELEMENTAL ANALYSIS

ELEMENTS 2/	% TOTAL COST	COST PER: M^2 1/	TOTAL
Substructure	2.00	0.03	3.30
External Walls	41.00	0.83	82.95
Roof	8.00	0.17	17.07
Doors and Windows	11.00	0.23	23.00
Plumbing System	28.00	0.56	55.70
Drainage System	10.00	0.21	20.70
Overhead and Profit	-	Incl.	Incl.
Contingencies	-	N/A	N/A
Total Cost	100%	2.027	202.72

1/ In this example the analysis is based upon the 100m^2 plot area. Another option would be to base the analysis on the developed area (slab on grade area). Which ever method is adopted, it must be standardised.

2/ The building elements are typical for the building type and the costs are for the complete system.

CONSTRUCTION INDUSTRY DATA FILE: FORM A (SEE ATTACHMENT A)

30. This is a general 'Industry Base' data file. It should be prepared as early as possible in the project cycle and submitted by the borrowing country. It should be updated at least twice each year. A further verification will be to have the data checked by Bank staff in the field periodically.

31. The file should be completed for each generic type and will include related key indicators. In the example shown, the generic type is 'Infrastructure' and the key indicators reflect typical construction components. Key indicators would also be prepared to reflect typical components of other generic types (simple housing, community facilities, etc.).

32. A future development of this data file could include a 'Cost Yardstick' section which would be the product of a quantity analysis of a typical hectare within a defined density range.1/ The Cost Yardstick would provide such details as manhours of skilled and unskilled labor; tonnes of cement; meters of drains and water pipes; etc.; all per hectare. The multiplication of these yardstick factors by their key indicator costs, would provide, in this case, a typical developmental cost per hectare for comparison with other projects.

1/ This information can be obtained using the "Bertauld Model" which is a design tool for evaluating alternative sites and service options.

CONSTRUCTION COST DATA FILE: PROJECT DATA: FORM B (SEE ATTACH B)

33. This is project related data, and should be submitted to the Bank by the borrowing country at the stages noted in the section "Basis of Cost Data", i.e. Pre-appraisal, Appraisal, Bid, Implementation and Completion. All data should be checked in the field by Bank staff.

34. The form includes a general section covering proposed densities and site data and a separate section each for water supply; sewage disposal; electrical supply; storm water drainage and circulation areas.

35. It is important to note that in each section the large proportion of data requested may be very simply calculated and requires little more than basic quantity and cost measurement. The derivation and use of this standard format however, provides a consistent process for cost analysis and therefore, useful tool for cost management.

CONSTRUCTION COST DATA FILE PROJECT SUMMARY: FORM C (SEE ATTACH C)

36. This is a Cost Summary form which may be derived from all the data contained in FORM B. The example shown is for INFRASTRUCTURE. This form should be incorporated in appraisal reports and should also be updated during the supervision phase periodically.

WORK PLAN FOR FUTURE PHASES

37. The following is an outline of tasks which should be carried out in future phases:

- run a workshop and test the proposed cost forms.
- prepare and test cost data forms for other generic building types.
- prepare a users manual incorporating a policy directive regarding cost management; a measurement guide and general directions for submittals.
- test complete system through at least three typical Bank projects, one of which should be a new project and the others ongoing.
- continuing development of the system would include the preparation of quantity factors for the development of typical "cost yardsticks". This would provide the Department with a sound basis for comparative cost analysis. These quantity factors may also be adopted for regional and time indexing.
- development of the system for mini-computers or word processors.
- run a series of training seminars for Bank staff and borrowing countries.

38. Exclusive of project based testing and the running of training seminars and workshops, the following level of effort is estimated:

		Man/Months
-	test and verify proposed forms	1
-	prepare and test forms for other generic types	11/2
-		
-	prepare user manual	11/2
-	prepare quantity factors for cost yardstick	11/2
-	develop cost indexing system	1
		6 man/months

FORM A

CONSTRUCTION INDUSTRY DATA FILE

BASE DATA

FORM A

CONSTRUCTION INDUSTRY DATA FILE

General Instructions and Definitions

<u>Shelter/Infrastructure</u>

off-site	- primary distribution
on-site	- secondary distribution measured from junction with primary system
on-plot	- tertiary distribution measured from connecting link to secondary system (manhole, meter, etc.)

<u>Economic Data</u>

Note that inflation rate and construction cost escalation rate are not necessarily the same. Also check assessments of rates in public and private sectors.

<u>Base Data</u>

Labor Costs	- basic wage rates
Availability	- identify (✓) whether local or imported
Materials	- all prices ex-warehouse - specify typical materials
Storm Water Drains	- describe or sketch system
Plant	- rental or amortised daily rates

<u>Key Indicators</u>

Prices and Review Data	- enter date completed in appropriate project cycle column
Material Prices	- ex-warehouse
Gasoline	- pump cost
Composite Unit Prices	- inclusive of labor, plant, overhead and profit - prices 'in-place' in building
Ventilated Pit Latrine	- price complete in place. etc.

FORM A

WORLD BANK
URBAN DEVELOPMENT DEPARTMENT
CONSTRUCTION COST DATA FILE

CONSTRUCTION INDUSTRY FILE
BASE DATA

BANK REGION ____________

COUNTRY ____________

SUB-REGION ____________

DATA SOURCE ____________

DATE ____________

BY WHOM ____________

Generic Type
SHELTER/INFRASTRUCTURE

off site	
on site	
on plot	

PROJECT NAME ____________

PROJECT NUMBER ____________

ECONOMIC DATA

Local Currency:

U.S. $ Exchange: = $1

As at Month ______ Year ______ Basis ______

Inflation Rate		Govt.	Market	Other
	Per Year			
	Per Month			
Construction Escalation Rate				
	Per Year			
	Per Month			

BASE DATA

INDICATOR	SPECIFICATION	COST			AVAILABILITY LOCAL	AVAILABILITY IMPORTED
LABOR	Skilled			per day		
	Unskilled			per day		
MATERIALS*						
Water Pipes		2"/50mm	3"/75 mm			
	a.			M		
	b.			M		
	c.			M		
Sewage Pipes		4"/100mm	6"/150 mm			
	a.			M		
	b.			M		
	c.			M		
Storm Water Drains	Closed System (spec)					
				M		
				M		
	Open System(specify)					
				M		
				M		
Footpath Materials (Typical for region)	a.			per tonne		
	b.			per tonne		
Road Materials (Typical for region)	a.			per tonne		
	b.			per tonne		
Cement				per tonne		
Transformers (pole mounted)	a. 50 KVA			ea.		
	b.			ea.		
Lighting Columns (6-8m complete)				ea.		
Water Meters (household type)				ea.		
Electric Meters (household type)				ea.		
PLANT						
Earth Moving	Include driver D6 CAT or equivalent			per day		
Trench Digging	Include driver ½ cy. backhoe			per day		
Hauling	Include driver Truck 5 ton tipper			per day		

*All prices ex-warehouse.

*Material Prices Ex-warehou:

Material/Item		Unit	Prices and Review Date									Remarks
			Pre-Appraisal				App.	Supervision			Comp.	
Concrete Blocks (solid)	100mm	Each										
	150mm	Each										
Lumber 50mm x 100mm												
1st quality		M										
2nd quality		M										
Galvanized corrugated iron sheet		M^2										
Gasoline		Litre										
The following composite KEY INDICATORS should be based upon a typical residential building floor area not exceeding $25M^2$.												
Excavating	Hand dig	M^3										
	Machine dig	M^3										
Concrete	1:3:6	M^3										
	1:2:4	M^3										
Block Walls	100mm	M^2										
	150mm	M^2										
Doors, complete with frame & hardware		Each										
Roof system complete with frame and sheet covering (roof area)		M^2										
Ventilated Improved Pit Latrine (or equivalent)	Substructure (including slab)	Complete										
	Superstructure	Complete										

FORM B

CONSTRUCTION COST DATA FILE

PROJECT DATA

FORM B

CONSTRUCTION COST DATA FILE

PROJECT DATA

General Instructions & Definitions

Basis of Cost	- insert date obtained against appropriate phase of project cycle
Type of Contract	- identify (force account, ICB, etc.)
Construction Period	- estimate of contract arrangements in months
Urban/Suburban Site	- identify (✓)
Measurement Generally	- follows rules identified in FORM A for off-site, on-site, on-plot
Materials	- specify materials to be used
Cost Data	- note that all costs are being used for comparative purposes and basis is total cost per sub-system (i.e. water, sewage; electrical supply; surface water drainage; and circulation areas)
U.S. Dollar Equivalents	- at current rates of exchange
Contingencies	- all prices should be exclusive of contingencies. See Form C for contingency additions.

WORLD BANK
URBAN DEVELOPMENT DEPARTMENT

CONSTRUCTION COST DATA FILE
PROJECT DATA
INFRASTRUCTURE

Project Type ______
Bank Region ______
Data Source ______
Date ______
By Whom ______

Project Title ______
Location ______
Site ______

Implementing Authority ______
Consultants ______
______
IDA CREDIT # ______
LOAN # ______

Brief Description of Project

Basis of Cost Data

Pre-appraisal	
Appraisal	
Implementation	
Completion	

Type of Contract ______

Construction Period ______

Total Site Area ______ ha
Total Population ______ persons (p)
Total Number Units ______ cores/houses (h)

Persons: hectare ______
Houses: hectare ______
Persons: house ______

Topography ______
Soil Conditions ______
Earthquake Zone ______
Water Table ______
Annual Rainfall ______
Rainy Season ______ months

Urban site	
Suburban site	

Distance from city center ______ km.

Off-site availability (describe)
Access ______ (roads)
Water Supply ______ (distance to mains)
Sewage Disposal ______ (availability)
Storm Drainage ______ (availability)
Electrical Supply ______ (availability)

WATER SUPPLY

Physical Data
Supply Pipes

Materials	Lengths (m) 2" / 50mm	3" / 75mm		Totals
a.				
b.				
c.				

Total length of pipe (all materials) ______________ m m/ha ________

No. water meters ______________ wm wm/ha ________

No. stand pipes ______________ s. s/ha ________

No. house connections ______________ hc hc/ha ________

No. fire hydrants ______________ fh fh/ha ________

Liters/capita/day ______________ lpcd

Cost Data

	Local Currency	U.S.$ Equivalent
Total cost water supply (TC 1/)		
Cost/meter pipe TC/M 2/		
Cost standard pipe TC/S 3/		
Cost/connection (household) TC/hc 4/		
Cost/ha TC/ha 5/		
Cost/person TC/p 6/		

1/ Note this is the total cost of water supply system.

2/ 3/ 4/ 5/ 6/ Total cost divided by total length of pipes; number of standpipes, connections, etc.

SEWAGE DISPOSAL

Physical Data
Sewage Pipes

Materials

Lengths (m)			Totals
4" / 100mm	6" / 150mm	/	
a.			
b.			
c.			

Total length pipes (all materials)__________ m m/ha______

No. of connections__________ c c/ha______

No. of manholes__________ mh mh/ha______

Liters/capita/day__________ lpcd

Other sanitation systems
Dry Systems

No. of pit latrines__________ PL

Water Systems

No. of aqua privies__________ AP

No. of septic tanks__________ ST

No. (other)__________

Cost Data

	Local Currency	U.S.$ Equivalent
Total cost system T/C/1		
Cost/m pipe T/C/M		
Cost/connection T/C/C		
Cost/latrine 2/ T/C/PL		
Cost/manhole T/C/mh		
Cost/person T/C/P		
Cost/ha T/C/ha		

1/ See notes on previous page
2/ Wet or dry system

ELECTRICAL SUPPLY

Physical Data

Incoming Service__________________

Transformers	K	V	A
No.			

TOTAL KVA ______

No. lighting columns complete lc

No. electric meters _______________ EM
(household)

KVA/ha _______________

lc/ha _______________

EM/ha _______________

COST DATA

	Local Currency	U.S.$ Equivalent
Total Cost Installation T/C		
Cost/KVA T/C/KVA		
Cost/lighting column T/C/lc		
Cost/meter (household) T/C/EM		
Cost/ha T/C/ha		
Cost/person T/C/p		

SURFACE WATER DRAINAGE

Physical Data

	Total Length (m)	
Open Drains (OD) (describe)		OD/ha______
Closed Drains (CD) (specify material)		CD/ha______
Total Installation	m	

COST DATA

	Local Currency	U.S.$ Equivalent
Total Cost Installation		
Cost/ha		
Cost/person		
Cost/household		

CIRCULATION AREAS.

Physical Data

	Material	Width m	Length m	Area m^2
Paved Roads (PR)	a.			
	b.			
Unpaved Roads (UPR)	a.			
	b.			
Paved Footpaths (PF)	a.			
	b.			
Unpaved Footpaths (UPF)	a.			
	b.			
Total Circulation (TC)				

Total paved roads/ha ______________________

Total unpaved roads/ha ______________________

Total paved footpaths/ha ______________________

Total unpaved footpaths/ha ______________________

Total circulation/ha ______________________

COST DATA

	Local Currency	U.S.$ Equivalent
Total Cost Circulation T/C		
Cost/m^2 $T/C_{/m^2}$		
Cost/household $T/C_{/ho}$		
Cost/person $T/C_{/p}$		
Cost/hectare $T/C_{/ha}$		

ATTACH C

FORM C

CONSTRUCTION COST DATA FILE

PROJECT DATA - SUMMARY

WORLD BANK

URBAN DEVELOPMENT DEPARTMENT

FORM C.

CONSTRUCTION COST DATA FILE

PROJECT COST - SUMMARY

PROJECT TITLE____________________ PROJECT NUMBER____________________

LOCATION____________________ DATE____________________

		Total System Cost		Cost per Hectare		Cost per Structure or Plot		Cost per Capita	
		Local Currency	$	Local Currency	$	Local Currency	$	Local Currency	$
Water supply									
Sewage Disposal									
Electrical Supply									
Surface Water Drainage									
Circulation Areas									
Contingencies	Price								
	Physical								
Total									