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REVIEW OF MAXULA RADES PILOT PLANT AND RELATED MODIFICATIONS WITH SPECIAL RECOMMENDATIONS FOR FUTURE US AID PARTICIPATION

by

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SUMMARY AND RECOMMENDATIONS

1. A thorough review has been made with the US AID MISSION and Directorate of Hydraulics of the GOT on the specialized sanitary system and scientific consultation services now being performed for the GOT on its design of an experimental ponding system for waste water treatment and disposal. It is concluded that the services of BCEOM are excellent.

2. GOT and BCEOM have agreed to incorporate recommended changes in design in the Maxula Rades system* to provide the opportunity to demonstrate a series of 4 specialized fermentation, mixing, sedimentation and maturation ponds in series in addition to the shallow ponds recommended by BCEOM. A revised design was forwarded to BCEOM on February 25, 1974 and these revisions are to be incorporated in the final design to go to bid in the near future.

3. As the existing system is completed and studied, it is likely that it will find widespread acceptance and use in many urban areas of the U.S.A. and of Tunis. Reclamation of useful irrigation water as well as excellent waste treatment is expected to be demonstrated if proper construction, start-up, operation, maintenance and monitoring of the system can be attained.

4. Start-up, operation and maintenance of the experimental system are of vital importance to the system's success and to avoid misapplication of the system. Accordingly, now that HAR and BCEOM have accepted design modifications, it would seem to be incumbent on US AID to follow up with technical assistance in start-up, operation, maintenance and monitoring advice. If such follow up assistance

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* The small stabilization pond system is to be located at Maxula Rades rather than Hammam Lif (see Figure 1).

is not provided, it would perhaps be best for the United States to withdraw the modified design before it is constructed.

5. US AID should determine if design modifications are indeed incorporated, and if they are, US AID should provide all technical assistance necessary to assure adequate start-up, operation, maintenance and monitoring of the Maxula Rades system in cooperation with MAR and BCLOM.

INTRODUCTION

The Directeur de l'Hydraulique et de l'Amanagement Rural (HAR) of the Government of Tunis (GOT), under Mr. Robert Samama, Directeur, has decided to construct a pilot plant stabilization pond in the vicinity of Maxula Rades, southwest of Tunis, near the Gulf of Tunis. The area in question is shown in Figure 1. The small series of stabilization ponds to be constructed will serve the current sewered population of Maxula Rades and will be operated to demonstrate the feasibility of stabilization ponds for Tunis and to explore such design variables as detention period, depth recirculation and loading.

MAXULA RADES SEWAGE CHARACTERISTICS

A review of the input information for the BCEOM ponding system follows.

The population served initially during the experimental study will be approximately 5,500 persons. The volume of flow from this contributing population is expected to average 880 m^3 per day, with peaks of 1,090 m^3 per day including an allowance of 430 m^3 per day, for infiltration and inflow. Daily unit consumption of water is assumed to average 0.108 m^3 per day with peaks of 0.151 mg^3 per day with 75% reaching the sewers in each case.

The above flow data is summarized in Table I which extends the information from 1973 to 1981. Generally average flows, rather than peak flows, are applicable for waste ponds because of the long detention periods and buffer characteristics of ponds.

TABLE I

PREDICTED FLOWS OF SEWAGE FOR MAXULA RADES, TUNIS
1973 - 1981
(After BCEOM)

Year	Period	Pop. Served By Water	% Conn	Unit Con m^3	% Disch	Disch Vol m^3/day	Inf Vol m^3/day	Daily Waste Flow m^3
1973	Avg.	15,900	35	0.108	75	450	430	880
	Peak	15,900	35	0.151	75	630	430	1060
1976	Avg.	18,700	44	0.112	77	710	430	1140
	Peak	18,700	44	0.158	77	1000	430	1430
1981	Avg.	24,600	63	0.121	81	1520	430	1950
	Peak	24,600	63	0.171	81	2140	430	2570

TABLE II

OBSERVED CHARACTERISTICS FOR SEWAGE OF MAXULA RADES, TUNIS 1973

(After BCEOM)

Characteristic	Sample 1 Off Peak Hours	Sample 2 Peak Hours
Organic Load		
DBO_5 mg/l	110	125
DCO mg/l	195	230
MES Totals mg/l	165	200
Phosphates PO_4 mg/l	1.7	1.9
Bacteriology		
Coliform	1.5×10^7	1.5×10^7
ESC coli	1.1×10^7	1.5×10^7
Fecal strep	4.3×10^6	9.3×10^7

The studies by BCEOM as shown in Table II indicated the sewage to be quite weak, the BOD_5 only 110 mg per liter and the COD, 195 mg per liter at off peak hours. At peak hours the BOD_5 was 125 mg per liter and the COD 230 mg per liter. Corrected for infiltration, according to BCEOM, the BOD would average 25 to 35 grams per person per day. Accordingly, the volumetric and organic loads to the ponds may be summarized as shown in Table III.

BCEOM EXPERIMENTAL PONDING SYSTEM

The experimental ponding system designed by BCEOM to accept the loads shown in Table III for the experimental period of one or two years is shown in Figure 2. As indicated in the figure, there are eight 0.5 hectare ponds, one 0.16 hectare pond (7.1) and one 0.33 hectare pond (7.2). In addition, there is an intensive aeration basin (BA), provision for recycle of effluents and provision for applying various proportions of the total waste to each of three series of ponds. The ponds may be operated at various depths from 0.75 meters to about 1.5 meters. Assuming the flow is distributed uniformly to each of 3 channels, and that the average load of 122 kg is applied, the loadings which may be explored are 250 kg/hectare per day and 61 kg/hectare per day. Assuming all loads were applied to the 0.16 hectare pond, a maximum load of 760 kg per hectare could be studied. With all flow directed to the 0.16 hectare pond operated 0.75 m deep, the shortest detention period would be about 1 day. With 1/3 of the flow directed to a single 0.5 hectare pond, with a depth of 1.5 meters and allowing for no evaporation or seepage, a detention period of 26 days and loadings of about 80 kg/hectare can be explored. These extremes well bracket the known limits for pond loading. The system is thus

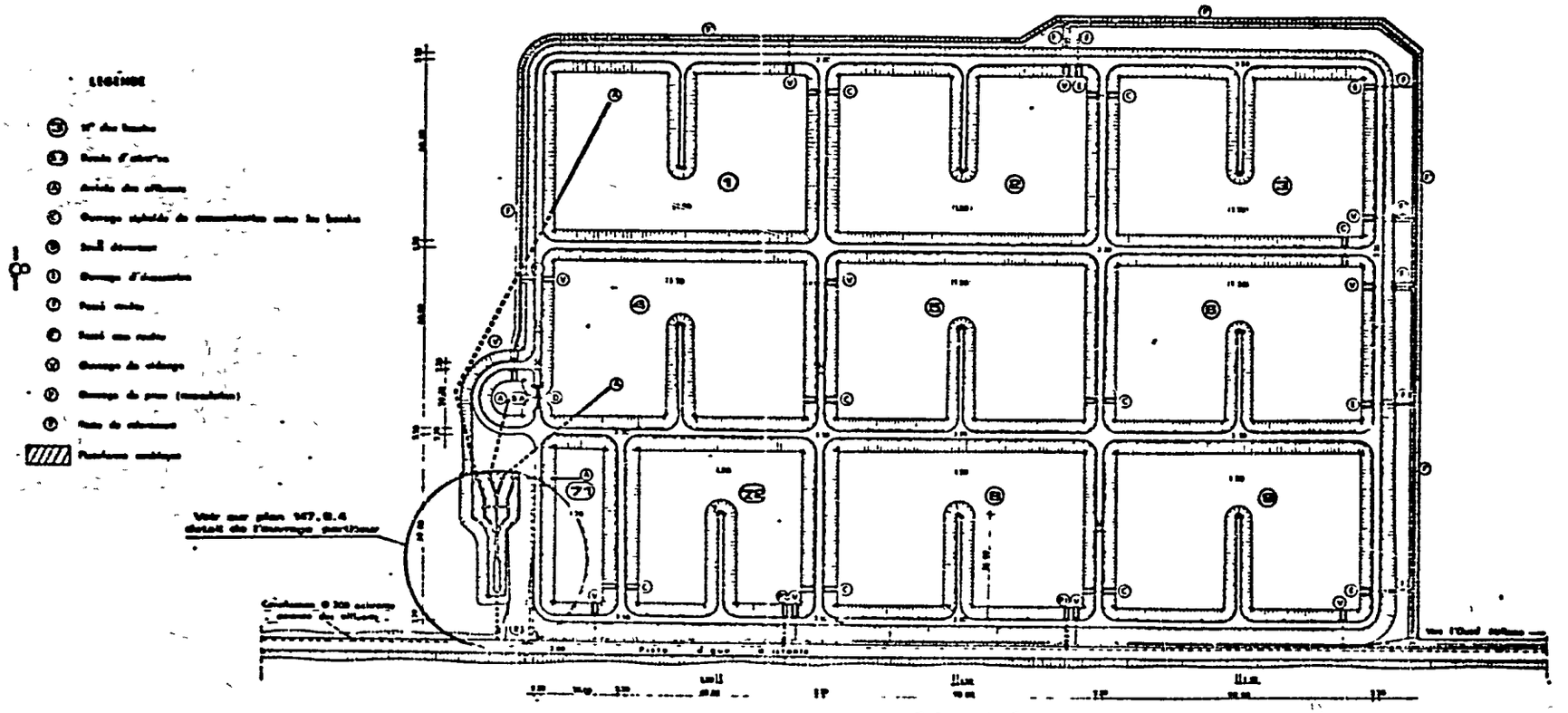


FIGURE 2
PRELIMINARY BCEOM DESIGN FOR EXPERIMENTAL PONDS AT MAXULA RADES

TABLE III

SUMMARY OF VOLUMES AND LOADS FOR MAXULA RADES, TUNIS
(After BCEOM)

Year	Period	Waste Vol m^3	Total BOD Load kg
1973	Average	880	122
	Peak	1060	170
1976	Average	1140	205
	Peak	1430	288
1981	Average	1950	489
	Peak	2570	689
1986	Average	3630	1152
	Peak	4980	1638

quite versatile from the standpoint of depth, detention period, loading and loading sequence. While it is an excellent and versatile experimental system for conventional studies, the system would not lend itself to exploration of the facultative, mixing sedimentation, maturation, four pond sequence which has been found a promising outgrowth of long term ponding research in California.

Directeur Samama, having seen the California research, expressed interest in incorporating the California design concepts in the Maxula Rades system. Accordingly, a meeting between HAR, the author and Mr. Jean Francotte of BCEOM was held in Tunis, under sponsorship of US AID and US EPA to explore design modifications of the BCEOM experimental system to permit the 4 pond sequence to be studied. Because of the versatility of the BCEOM design, it was found that only relatively minor modifications in the original BCEOM system were required to permit the Berkeley system to be explored in Maxula Rades experiments.

Accordingly, design modifications were requested by BCEOM and these were forwarded to BCEOM on February 25, 1974.

MODIFIED POND DESIGN

The modified system design, is shown in Figure 3. Schematic diagrams of certain details of the system design are shown in Figures 4,5,6,7,8,9, and 10.

The basis and rational for the modified design are first that methane fermentation is the "sine qua non" of long term dependable treatment of wastes in stabilization ponds, and that shallow ponds

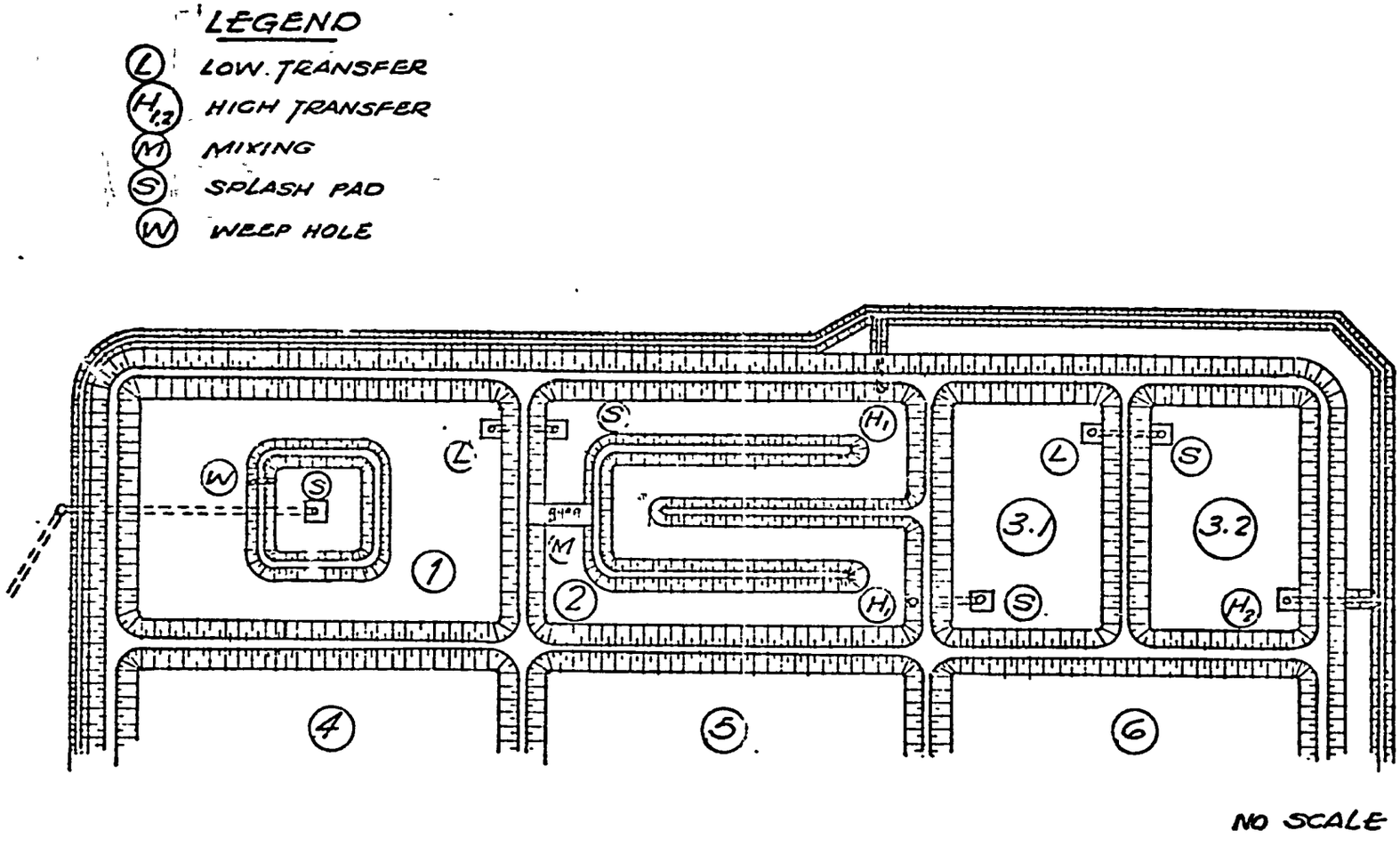
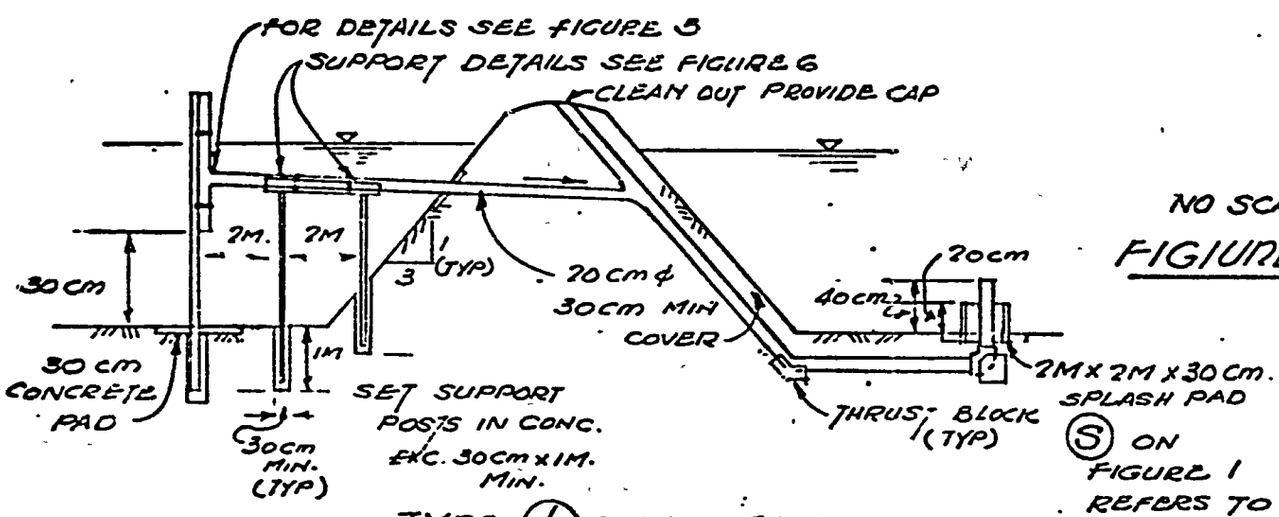


FIGURE 3

EXPERIMENTAL PONDS MODIFIED FOR BERKELEY SYSTEM IN PONDS 1, 2 AND 3.1-3.2



TYPE (L) TRANSFER.

FIGURE 4 NO SCALE

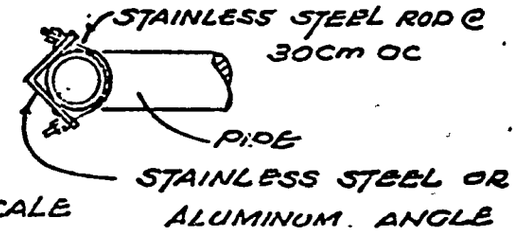


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FIGURE 7 VERTICAL EFFLUENT PIPE SUPPORT.

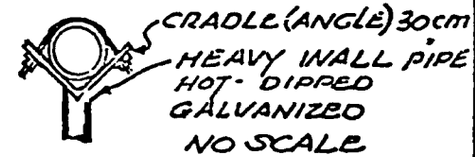

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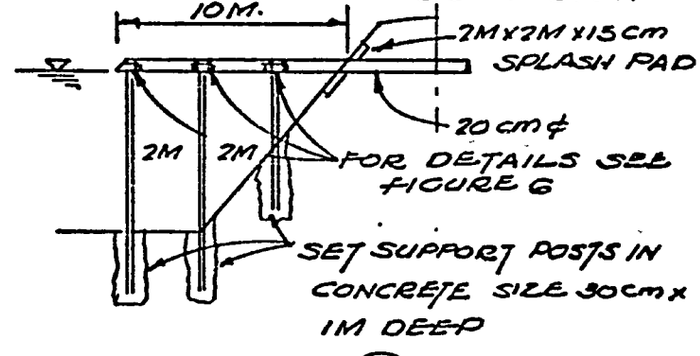
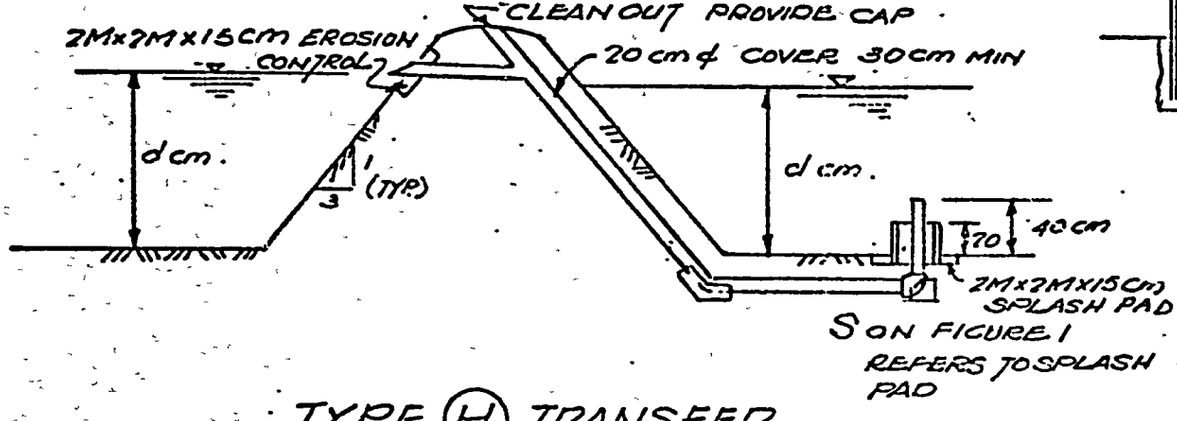
FIGURE 8 HORIZ. PIPE SUPPORT.



TYPE (H_2) TRANSFER

FIGURE 6 NO SCALE



TYPE (H_1) TRANSFER

FIGURE 5 NO SCALE

NOTE

L, H_1 & H_2 REFER TO TRANSFER STRUCTURES SHOWN SCHEMATICALLY ON FIG. 3

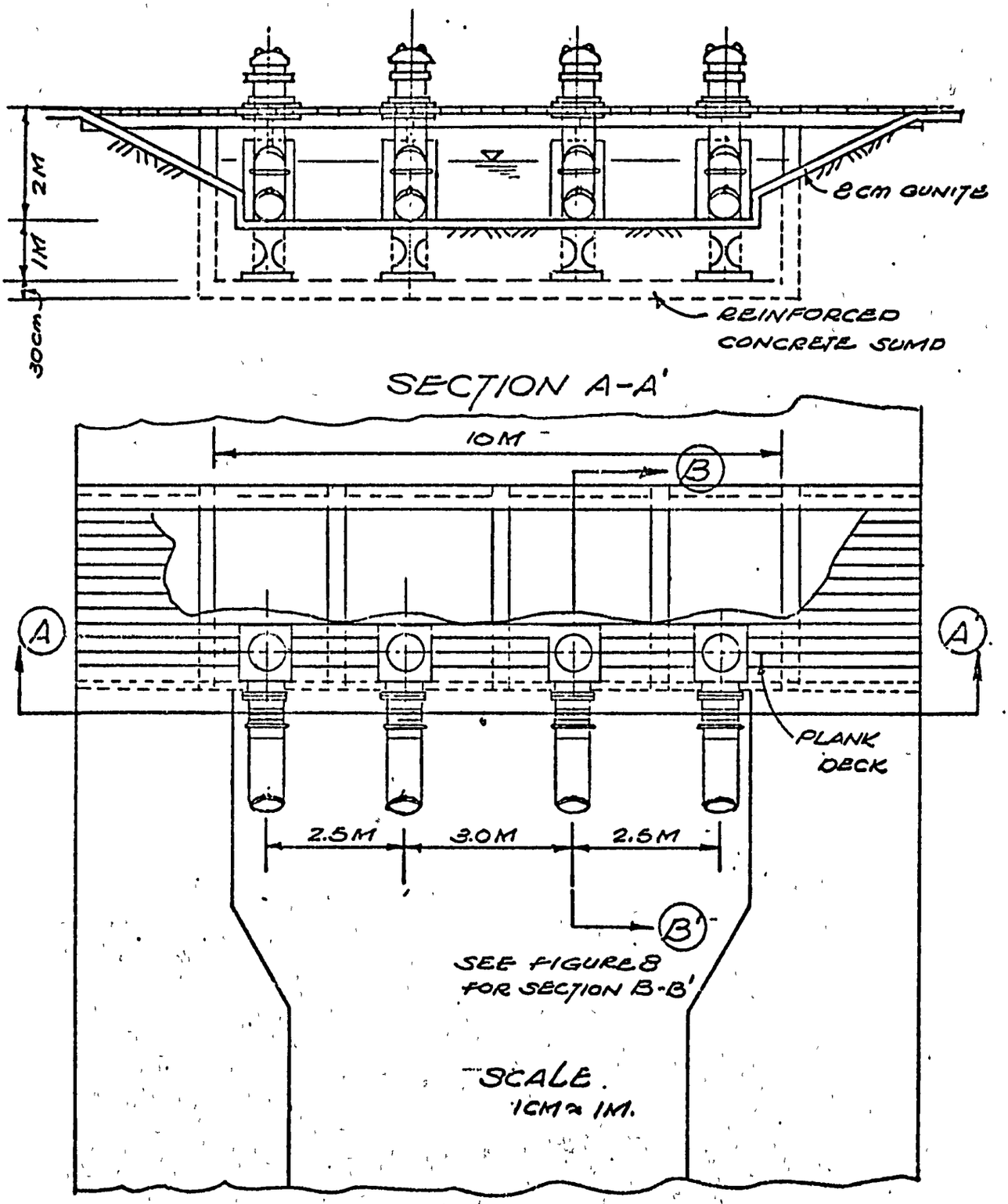
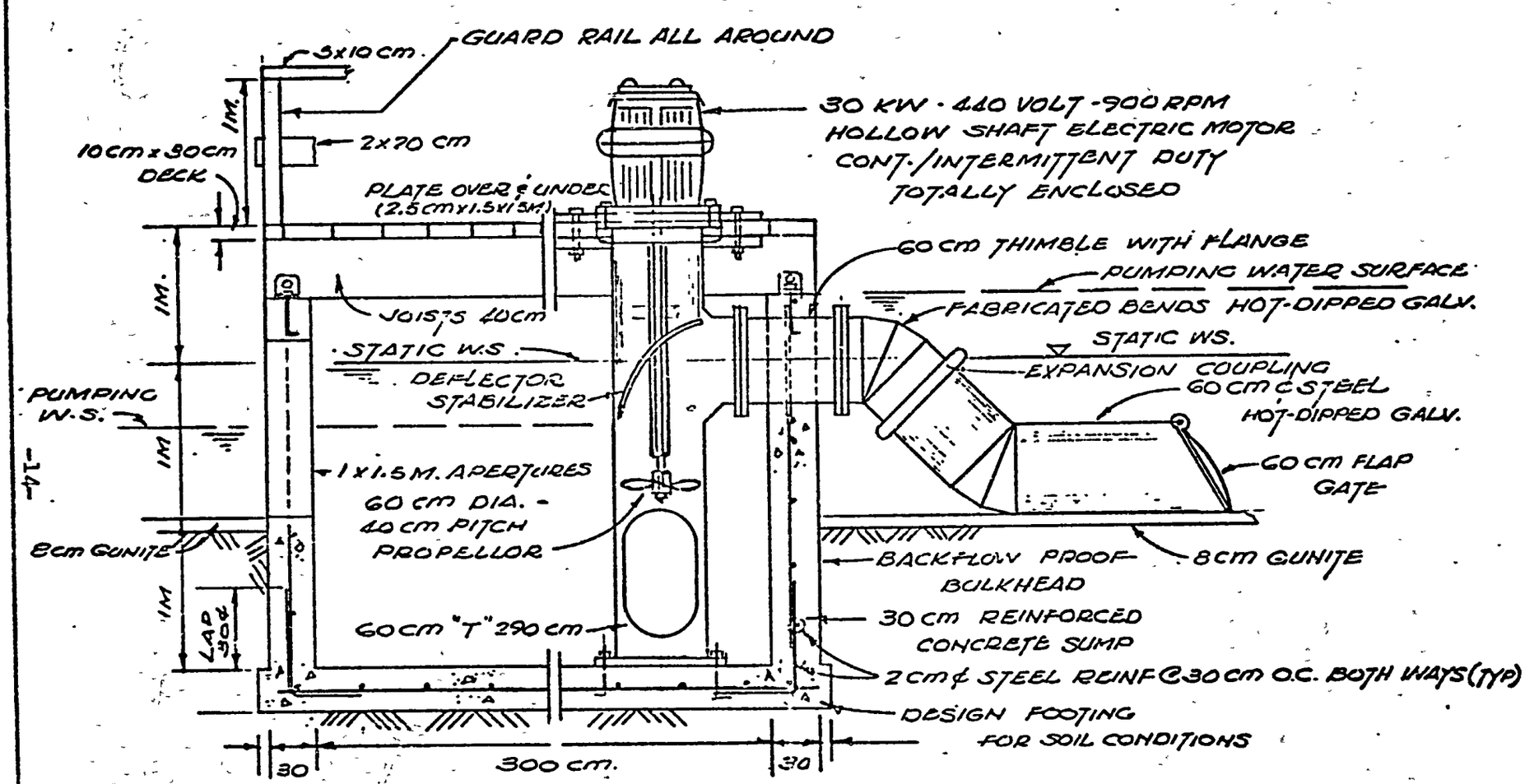


FIGURE 9

PUMPING STATION DETAILS



NO SCALE

SECTION B-B'.

NOTE:

4 COMPLETE PUMPS REQUIRED
DESIGN SPECIFICATIONS
$1M^3$/SEC AT 1 METER
DISCHARGE HEAD

FIGURE 10

FLOW INDUCING PUMP SHOWING SUMP AND MOUNTING DETAILS

easily overturned by the wind are not an ideal environment for a stable dependable methane fermentation. Accordingly, pond number 1 is shown to be modified to have within it an isolated volume dedicated to methane fermentation. This volume is implanted within the center depths of the pond and is unseen when the pond is full. Nevertheless, sedimentation of most of the sewage primary sludge will occur within this volume. After fermentation has started, as much as 70 percent of the applied BOD may be dissipated through fermentation in this center volume. Most odors in the gas bubbles emerging from this volume will be absorbed by the overlying algae culture which will be rich in oxygen and have a high pH.

Grease and floatable solids are retained in the first pond (pond 1) because water transferred to the second pond of the series (pond 2) is from near the bottom of the first pond. This is the coldest water and will have a high coliform count. The second pond is optimized for algae growth by being shallow and subject to periodic channelized mixing. In this channel, algal growth is maximized and, due to carbon limitations, the pH of the solution is increased. The water is heated by the interaction of sunlight and algae and consequently a substantial oxidation of the remaining BOD and a substantial killing of pathogenic bacteria and viruses occurs. Water is skimmed from the surface of the mixing pond and transferred to the bottom of pond 1.1 where sedimentation of algae occurs. The water is transferred from pond 3.1 to 3.2 by means of a deep intake. The water transferred is relatively free of algae and E. coli. Final removal of water from pond 3.2 is made from the surface, a distance from the levee. This is the highest quality water and should be demonstratably suitable for irrigation of plants such as wheat, corn or grapes.

Arrangement of the transfer structure shown in Figures 4, 5, and 6 is based on the finding that for ponds which discharge effluents, and therefore should discharge few pathogenic bacteria, the minimum number of ponds in series is 4. This has been demonstrated through experimental results and is theoretically sound on the basis of short circuit analysis.

Our studies indicate that aside from detention time and temperature, the most important factor contributing to short circuiting and failure in disinfection in ponds is the difference in temperature of the sewage and the pond water, and the vertical location of the transfer intake. The primary pond must have a low level transfer unit to avoid discharge of floatable solids and grease, and to remove the colder water from the first pond. Further, the final pond must have a surface transfer discharge to decant the best water for discharge. With 4 ponds in series, and alternate deep and shallow transfers, one obtains the maximum possible disinfection for a given detention period. A relationship between temperature time and disinfection in a single facultative pond is shown in Figure 11. Although better performance than shown is attained in a series of ponds, the exact relationship is not developed.

Properties of the modified ponds of Figure 3, in terms of depth, area, volume and detention period, allowing for evaporation, are shown in Table IV. As indicated in Table IV, if 1/3 of the flow is passed through the 4 pond modification, a total detention period of 106 days may be obtained. With half the flow, an overall detention period of 70 days would be attained, and with the total flow a detention period of 35 days would be attained.

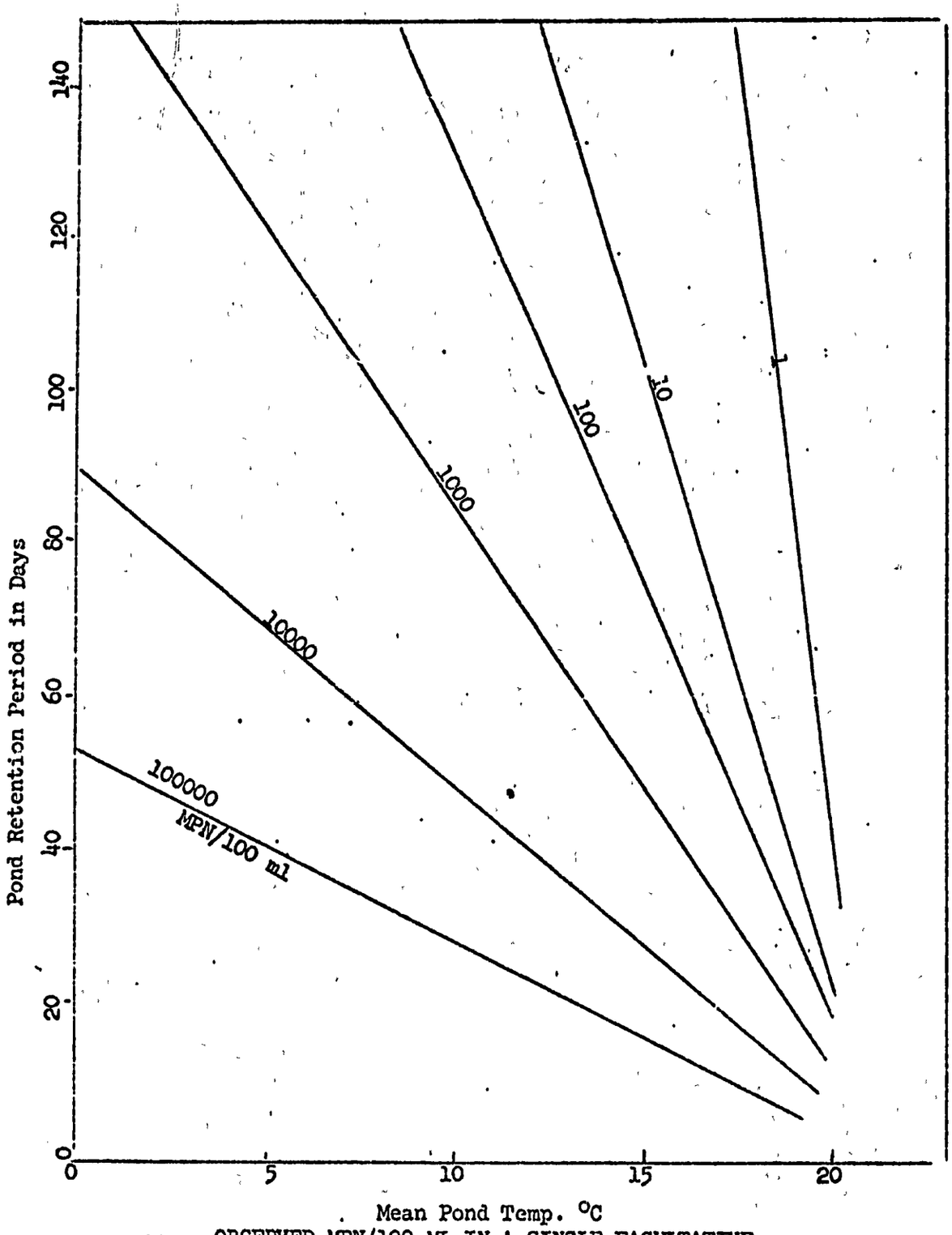


FIGURE 11: OBSERVED MPN/100 ML IN A SINGLE FACULTATIVE POND AS A FUNCTION OF TIME AND TEMPERATURE INITIAL MPN 10^8/ML

TABLE IV

PROPERTIES OF SERIES PONDS IN
BERKELEY MODIFICATION OF BCEOM DESIGN

Pond No.	Depth m	Area m^2	Volume m^3	Cum Vol m^3	Norm Det Days @ 292 m^3/day **	Evap Corrected Det Days	Cum Days
1	1.8	5000	9300+	9300	31.8	293-35 36.3	36.3
2	1.0	4400	4400	13700	15.0	256-35 19.8	56.1
3.1	2.5	2500	6250	19950	21.4	221-17 30.4	86.5
3.2	1.5	2500	3750	23700	12.8	204-17 20.2	106.7
TOTALS		14,400	23,700	23,700	81.0	106.7	106.7

+ Includes volume of depression

** 1/3 of Mean Flow

The minimum feasible detention period for the Berkeley system is believed to be about 40 days. Under those conditions, according to Figure 12, BOD removal will be 90 percent, but according to Figure 11, E. coli concentrations may be 10^4 or greater. It is believed that E. coli concentrations of 10^3 are at the limit of permissability for irrigation water. However, experimental determinations will be required to demonstrate attainable disinfection and the limits of the system under conditions at Maxula Rades.

EXPERIMENTAL PROGRAM

The experimental program for the Berkeley modified ponds will be to operate the system at overall detention periods of 35, 70 and 100 days and to study water quality in each stage of the system. Accordingly, there will be five samples: 1. influent, 2. pond 1 effluent, 3. pond 2 effluent, 4. pond 3.1 effluent, and 5. pond 3.2 effluent. The samples will be tested for BOD, COD ph, alkalinity, temperature, complete solids, chlorophyll, total, ammonia and nitrate nitrogen, total and orthophosphate and total and fecal MPN. Gas production and quality in pond 1 will also be studied. Each series should be run for several months with daily observations prior to the final testing program before a complete evaluation of the system can be carried out. At least 3 complete evaluation series should be run for each set of experimental conditions.

These studies will, of course, be run in parallel with the BCEOM and MAR studies of the other two series of ponds in the experimental system Combined and cooperative testing will be practiced insofar as possible throughout the experimental program. Ideally, each experimental program will reinforce the other.

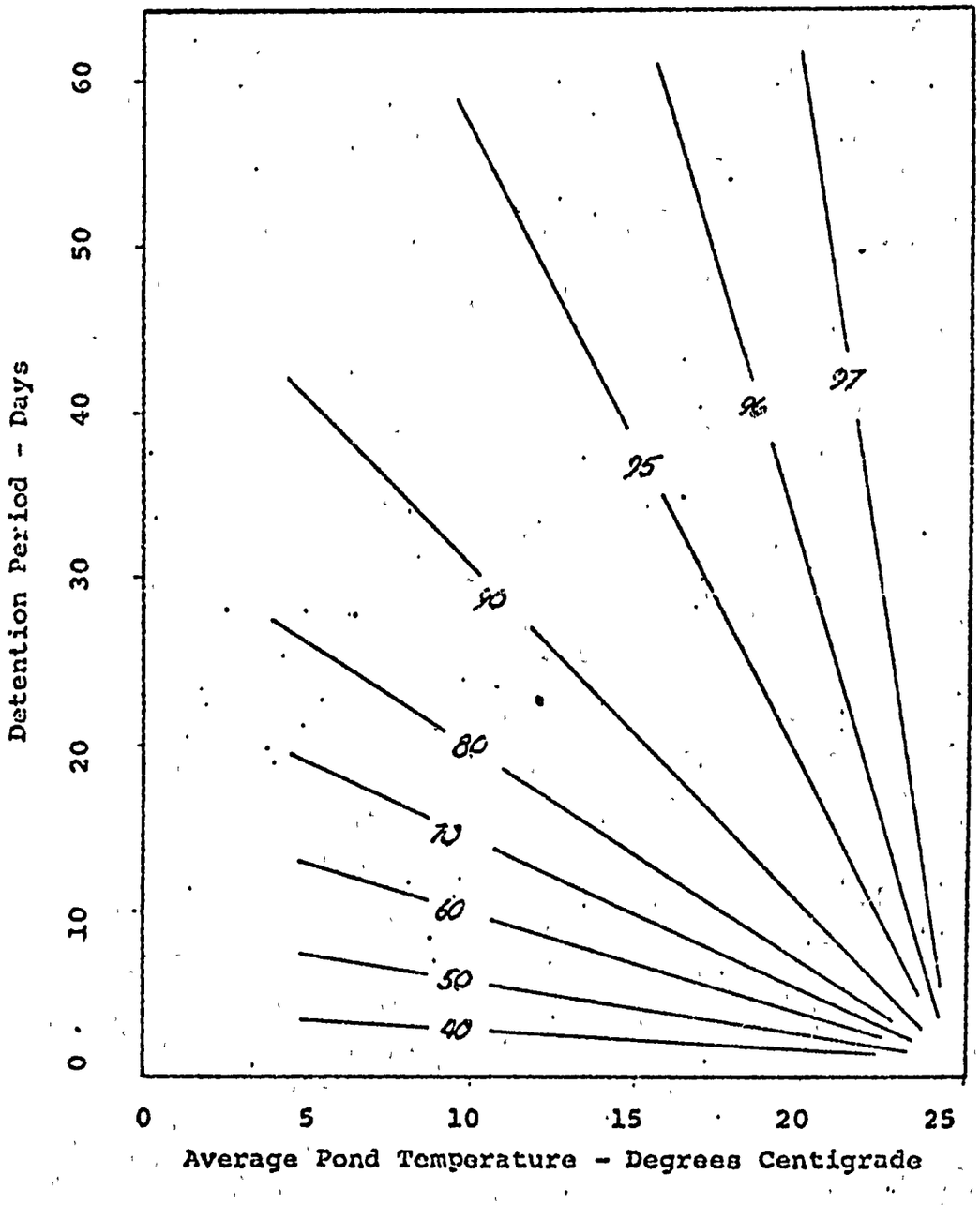


Figure 12 % BOD Removal in Facultative Ponds as a Function of Time & Temperature.

PROGRAM SUPPORT

Adequate competent technical guidance in construction, start-up, operation, maintenance and monitoring of this system is crucial if the program is to succeed. Accordingly, USAID should make a decision soon to continue the program or withdraw from it. If the decision is to withdraw, Samama should be informed so that the recommended modifications in the BCEOM design can be withdrawn also. It is, however recommended that USAID and EPA fully support this program as it is both a unique opportunity to improve the state of the art in advanced waste treatment for the USA and to transfer a valuable, easily applied technology to the Country of Tunis.

OTHER ACTIVITIES DURING VISIT OF FEBRUARY 1974

In addition to meeting with HAR and BCEOM on the Maxula Rades design, conversations were carried out with a view to developing modifications of other systems in Tunis applicable for irrigation water production for use in communities,both in the United States and Tunis,as well as elsewhere. A complete review was made of the report and lakeside activities of the Swedish government in restoration of Lake Tunis. Also reviewed was the EPA/Smithsonian base line survey of Lake Tunis which is now being conducted by a Duke University team under the project monitorship of Mr. Tom Maloney of the Pacific Northwest Water Laboratory of EPA.

Swedish Government Work

The Swedish government work currently involves the construction

of large retention reservoirs where sludge dredgings from near the La Cherguia outfall may be held and deactivated. Later, the effluent from La Cherguia will be impounded and aerated prior to release into Lake Tunis. This is an interim program designed to control odors in Lake Tunis and is not regarded as a substitute for the recommended ultimate removal of La Cherguia effluent from Lake Tunis. Recommendations for treatment systems to treat the entire waste of greater Tunis to an extensive degree are now in the formative stage, but no definite decision has been made by HAR as to the type of treatment which will be used and the ultimate disposition of the effluent. Mr. Samama has suggested a review of a recent feasibility study made by a European engineering firm. CSO stands ready to make such a review.

EPA Lake Study

The EPA base line study is underway providing a once in a lifetime opportunity to observe the progress of restoration of this unique shallow estuarine system from beginning to end. A considerable quantity of data has already been collected and as the Swedish government modification of the lake begins to be applied, quality changes in the lake should appear. The presence of the Smithsonian Marine Sorting Station in Tunis is a definite benefit to this project, not only from the standpoint of training and staffing, but also because of logistic and technical support. However, because of the specialized nature of the Duke data collection, a separate analytical laboratory is being established in Kherradine near Tunis. This laboratory, or a branch thereof, may also serve as a base for data acquisition should the Maxula Rades pond study be conducted.

CLOSING STATEMENT

In view of the generous concessions made by HAR and BCEOM

in agreeing to modify the Maxula Rades experimental system to permit the 4 pond series experiments to be conducted, and in view of the fact that considerable additional expense will accrue to HAR because of these modifications, it now appears incumbent upon USAID to reach an early decision on further support of these studies and to encourage a full scale EPA exploration of the experimental units in cooperation with HAR and BCEOM. CSO International, Inc. stands ready to plan and carry out the engineering details of the complete study in accordance with the terms of our proposal of September 28, 1973, or any reasonable modifications thereof.