POSSIBILITIES OF FISH CULTURE IN PONDS IN WESTERN SAMOA

A report by

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PREFACE

It can almost be said that before it really existed, the South Pacific Commission was interested in the development of fisheries, for one of the projects which the Canberra South Seas Conference of 1947 (at which the Commission was established), recommended for early consideration as being of great importance to the economic and social welfare of the local inhabitants of the non-self-governing territories in the South Pacific was:-

> "fisheries research, including surveys and the testing of methods of catching and of processing fish and other marine products with the special aim of improving the nutrition of the local inhabitants".

Fisheries Methods was one of the subjects discussed at the First South Pacific Conference at Suva in 1950. The assembled delegates of the people of the island territories recognized the importance of fisheries in the South Pacific area, both as a source of economic wealth and a means towards improved food supply of the inhabitants, and listed a number of associated aspects for the special attention of the Commission.

These and other proposals for Commission activity in this field, led to the holding of a Conference of fisheries experts at Noumea in May 1952 to define more precisely the work which should be undertaken by the Commission. The objectives of the Conference were described as:-

(a) To work out a practicable method of bringing together all the relevant information available on fisheries in the region;

(b) To suggest the best way of investigating quickly the problems of catching, processing, transporting and marketing, and of inducing people to increase the use of local fisheries products;

(c) To make constructive suggestions concerning a statement of the prerequisites for fisheries development in the region;

(d) To consider and advise what role the South Pacific Commission could play in the development of the fisheries in the region.

The Report of the Fisheries Conference (S.P.C. Technical Paper No. 25) was accepted as the basis of the Commission fisheries programme.

In the light of that report and further recommendations from the Research Council and Second South Pacific Conference, Mr. H. van Pel has been engaged by the Commission as Fisheries Officer to carry out investigations and other activities in accordance with the Commission fisheries project. In particular, he is required, as a Commission specialist and in consultation with territorial administrations, to assist and stimulate fisheries investigation and development in the Commission area, including inland fisheries and pond culture.

Mr. van Pel's early experience in the fishing industry included six years as skipper of a steam trawler operating in the Atlantic and North Sea. In 1932, he joined the Netherlands East Indies Government as a fisheries officer, finally being appointed Director of the Bureau of Fisheries, East Indonesia. In 1951, he joined the Food and Agriculture Organization, and was sent to Pakistan to design a fishing harbour at Karachi. He later went to Liberia to train fishermen there in modern fishing methods.

Since assuming duty with the Commission in July 1954, Mr. van Pel has already visited Netherlands New Guinea (twice), Fiji, Western Samoa, American Samoa, Tonga and the Cook Islands. His reports on fisheries developments and prospects in each territory are being made available, with the concurrence of the authorities concerned, for the information of other governments, territorial administrations and institutions to whom they are likely to be of interest.

Noumea, New Caledonia. June, 1955.

POSSIBILITIES OF FISH CULTURE IN PONDS IN WESTERN SAMOA

A visit to Western Samoa was made from August 29 to September 8, 1954. During this period, I was asked by Mr. Eden, General Manager of the New Zoaland Reparation Estates, to investigate the possibilities of establishing fish ponds near Apia, in the island of Upolu. He specifically wanted to ascertain whether some mangrove areas flooded at high tide could be made into brackish water ponds. Some fresh water streams on the Estates were also visited in Mr. Eden's company, but their surroundings did not prove favourable, the rocky ground being an indication that the bottom would not be fertile and that the cost of laying out a pond would be prohibitive. Other likely sites in connection with both fresh and brackish water supplies were seen outside the Estates, but there was not time to investigate them.

In the Estates, the only likely prospect was found in the mangrove area of Tuanaimato. According to Mr. Eden, 21 acres of ground can be turned into fish ponds. It was at first intended to raise Milkfish, Chanos chanos Forsk.. This species is raised in ponds in Indonesia, Malaya, the Philippines, India and some of the South Pacific Islands. It is regrettable that I did not find any milkfish fry around Upolu. It should be mentioned that local fishermen did not recognise the photograph of Chanos I showed them.

This report is being written to cover specifically only the technical data necessary for the building of fish ponds in the Sogi area.

I.

GENERAL

There is a serious shortage of fish in Western Samoa, and fish is very expensive in this territory. Most of the supply is caught on the lagoon reefs and it can be said that these are already overfished. Consequently, any increase in the supply must come from pelagic fisheries or from inland fisheries. There being no large rivers or lakes, the bulk of any additional supplies should be expected from the Ocean, provided funds and fishermen are available. The simplest and least expensive method, however, involves the establishment of fish ponds.

I gathered the impression that the quantity of food available to the islanders of Upolu is adequate, but that the animal protein ration was low. Although fish ponds cannot provide a complete solution of this problem, the contribution they could bring would be welcome.

The only area offering possibilities for rational pond culture in New Zealand Reparation Estates is the brackish water mangrove of Sogi. The following data were therefore obtained from the Apia Observatory:

1. Sea water temperatures near shore (appendix I)
2. Sea water densities near the coast (appendix I)
3. Mean air temperatures 1949-1953 (appendix II)
4. Monthly rainfall 1949-1953 (appendix III)
5. Number of rain days per month 1949-1953 (appendix III)
6. Mean monthly wind speed for 1953 (appendix III)
7. Wind directions 1953 (appendix III)
8. Daily sunshine 1953 (appendix IV)
9. Rising and falling of tide (appendix V)

From the laboratory of the Government Hospital I obtained analyses of water samples collected near the proposed site of the fish ponds, these will be found in appendix V.

The above mentioned data of appendices I to V are normal. Rainfall is irregular.

A layer of bluish clay 15-20 inches deep is found at the surface of the ground, the substratum being black sand over a hard bottom situated at a depth of five feet. The nature of the hard bottom could not be investigated but it is thought to be of volcanic origin. In any case, it is not likely to cause any trouble, since it would lie one foot below the bottom of the pond. Four test holes 3'4" deep were made in order to assess the porosity of the soil. The level of groundwater in these holes remained unchanged during the whole of my stay.

Low mangrove bushes are growing in the surrounding area. Next to the mangrove lies an open space covered with stem-grass, which Mr. Eden would prefer to use for the time being since it is easier to watch, although the area adjacent to the tidal creek would be more suitable for the establishment of a fish pond.

Milkfish fry was sought along the coast of Upolu, and a scoop net and a lure were prepared for this purpose (see Plate 3). Not a single specimen of milkfish was found either around the lure at high tide or in the tide pools at low tide. It is possible that Chanos fry could be found there at some other season but I doubt it, since the local fishermen were not acquainted with this species. Fry of unidentified Mugilidae was caught near the lure. Numbers of small mugilidae and small shrimps were observed in the tidal creek.

In spite of the name of "tidal creek" given to it, there is plenty of fresh water coming into this stream (see Plate 2). Indeed, I have found fresh water in it 400 yards inland, at the Savalalo bridge. Water flows to the creek from the Vaoa spring, at the foot of Vaoa Mountain, as well as from many other sources. The creek actually carries a mixture of fresh and salt water, and this can be expected to continue all the year round, since the spring never fails. It is not expected that the salinity of a pond in this area would be very high.

As it is intended to raise Tilapia (see Plate 5), the water in the pond should be left stagnant. Losses by evaporation will be offset by rain, although water can be admitted through the sluice gate if necessary.

II.

THE SPECIES OF FISH TO BE CONSIDERED FOR STOCKING THE PONDS.

As far as I could ascertain from the brief investigation carried out, milkfish can be disregarded, since no fry was found. This fact is regrettable, as circumstances were otherwise favourable. Wildfish have also been disregarded. This leaves only one important possibility: Tilapia mossambica Peters. This species has become very popular in the last few years. It is easy to raise in fresh or brackish water ponds. Tilapia raising is now common in Thailand, Malaya, Indonesia, and small ponds have recently been stocked in Fiji.

In a booklet entitled "How to raise fish for food", published in 1953, Mr. S. Y. Lin, Fish Culturist of the F.A.O. states:

> "The Tilapia mossambica Peters is a native fish of Africa, but closely related to the South American Cichlids. It feeds on algae, worms, insects, cereals and oil cakes and grows to about 1 kilogram a year in brackish water ponds with artificial feeding. The meat of Tilapia is tender, boneless and with excellent flavour. In clear water ponds with sandy, gravel or even muddy bottom it multiplies rapidly; a few hundreds of Tilapia in a pond will be able to reproduce several thousands in 1 or 2 months' time".

Baas Becking wrote, in his Report on the Examination of Sites for Fishponds in Fiji:

> "At Buitenzorg, the author obtained a yield of 1500 lbs/acre (Tilapia), using a fresh water pool with sewage effluent, in six months. A slightly greater yield was obtained 6 months later."

It was ascertained while passing through Fiji in September 1954, that 52 Tilapia fingerlings had been obtained from Singapore for that territory. Survival at destination was 100%. These fingerlings were placed in a pond half a square chain in area, at Sigatoka, on the 28th January 1954. On March 29th, the pond was found swarming with Tilapia mossambica fry. It was evident that in exactly 2 months, the Tilapia had grown from fingerlings two inches long into adult fish and spawned (see Plate 5).

The Malayan Department of Fisheries has obtained annual yields of 1065 pounds per acre, and one Chinese fish farmer established in Malaya has obtained a steady yield of 800 pounds per acre per year over 25 acres of ponds.

Conclusions may easily be drawn from the indications given above. However, warning is issued here that a reasonable yield depends on the proper care given to the pond, the water, fish-food and stock fish. Lack of care will prevent the growth of fish in a pond, although they may be plentiful.

In my opinion, Tilapia mossambica is the most suitable fish for stocking ponds under the conditions set out above. It is also the easiest to raise. It is evident that it would be preferable to investigate all factors for a whole year, but this would involve a great deal of expense and even then, there might still be some uncertainty on a few points. It is much cheaper to start with an experimental pond and stock it with Tilapia.

Tilapia fingerlings can be ordered from Mr. W.J.A. Payne, Sigatoka Agricultural Station Fiji, through the Director of Agriculture, Suva, Fiji, at the cost of one shilling each. The best would be to order 50 fingerlings and to have them sent by air.

III.

RAISING TILAPIA MOSSAMBICA

This species can be raised in ponds built as indicated in Figures 1 to 5. However, there is raising and raising, and the idea here is to get the maximum possible returns. With this end in view, fish-farming should be the only objective. Since it is intended in this case to start with an experimental pond, expanding the project into a commercial venture if success is achieved, I advise starting with a combination of ponds such as shown in Figure 1 (Plan) and Figure 2 (Profiles). Such a combination is more expensive than a single pond, Figure 4 (Plan) and Figure 5 (Profiles), but permits of forecasting future yields with great accuracy. Afterwards single ponds can be made as shown in Figure 4 for raising.

Practice has taught us that optimum results cannot be obtained by mixing fishes of different sizes. Therefore, pond A is intended for the fry to fingerling stage, pond B would receive the fingerlings and bring them to half normal size, when the fish would be transferred to pond C for the last stage after which they would be of a size suitable for consumption.

However, some mixing of sizes cannot be prevented, and it is impossible to have 100% segregation in actual practice, although it is advisable to carry it on as far as possible. Afterwards in the second generation, sexing has to be done and only males will be raised.

Upon receiving Tilapia fingerlings from Fiji, it would not be advisable to put them straight in pond A, since they will have come from fresh water. They should be put in a tank full of fresh water, which will be replaced by brackish water. This operation can be carried out in a couple of days. After one day, one quarter of the fresh water is replaced by brackish water. After two days, half of the tank is emptied and filled with brackish water. On the third day the fingerlings can be put in pond A.

Pond A will have been filled ten days prior to introducing the fingerlings in it. A sieve should be installed in the sluice gates leading to D and A, in order to prevent admission of predatory fish. This sieve can be made of perforated rink plate and has the dimension of a wooden sliding board (Fig.3).

It is advisable to use organic fertilizers, unless there are likely to be objections to this practice. Cattle and horses are available in numbers on the Reparation Estates, and could provide large quantities of manure. Pond A requires 2 gallons (9 litres) of manure per week. Pond B requires 6 gallons, and pond C, 23 gallons a week. The pond in figure 4 requires 35 gallons of manure a week. It is best to use fresh manure, which is first mixed with a small quantity of water (from the pond) and then spread over the surface. There is no objection to manuring twice a week, provided half the above mentioned quantities are applied each time. The ponds are shallow, and the action of the sun and the fertilizer will produce enough food for the Tilapia.

When it becomes necessary to transfer some fish into another pond, the best method is to drain the pond until a small pool of water is left in front of the sluice gate, just before the tide starts rising again. This involves the loss of fertilized water, but this is compensated by the elimination of undesirable fish. Springtides offer the best oocasions for draining and filling.

The rate of filling or draining is 50 cubic feet per minute. The speed of the water in the sluice will be 1 foot per second. The calculated total time of filling or emptying is:-

Pond A	53 minutes
" B	2 hours, 49 minutes
" C	11 hours, 32 minutes
Experimental Pond (Figure 4)	17 hours, 53 minutes, but in case of emergency this time could be halved.

A fish pond should be drained for disinfection at least once a year, and must remain dry a couple of days. Surface plants are not a desirable feature, since they prevent the bottom of the pond from receiving direct sunlight, thus restricting the growth of algae etc...

According to le Mare, Director of Fisheries, Federation of Malaya and Singapore, Tilapia grow more rapidly and reach a larger size in brackish water than in fresh water.

IV.

BUILDING THE PONDS

One of the first considerations, when digging the ponds, should be to obtain a good drainage of ground and rain-water. A bulldozer is available, but it cannot work in water, so trench E and the sluice gate leading to it should be prepared first. The next step will be the division pond D. For the other ponds, sluice gates must be built first before the digging operations can be initiated. It would be best to start with the small pond.

The earth excavated can be spread over the surrounding ground. The sloping walls, the bottom of the ponds in the vicinity of the sluice gates, and the bottom of the sluice boxes must be well tamped. It would be advisable to grow plants (e.g. some kinds of grasses but no trees) suitable for earth-holding on the wall slopes.

Before the wooden sluice gates are installed, they must be entirely tarred. All further data can be found in the drawings. Figure 2 should be read in relation with Figure 1, and Figure 5 in relation with Figure 4. The dimensions indicated have been computed in connection with the available open space at the proposed site, but strict adherence to these is not necessary, except in the case of depths. The depth in all

ponds should be such that the level of the water in the shallow part will be 2 feet 4 inches and in the deep part 3 feet. The bottom of the Division pond and Trench is 4 inches deeper than the deepest part of the pond bottoms (see Figures 2 and 5). The slope of the pond borders should not be more than 45 degrees. The sluice gates (Figure 3) are the same in all cases.

APPENDIX I

MEAN MONTHLY SEA TEMPERATURES, 1953

JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
84.2	84.5	84.9	85.1	83.0	82.0	80.6	79.6	80.5	81.8	83.0	83.9	82.8

MEAN MONTHLY SEA DENSITIES 1953

JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
1.0238	1.0239	1.0237	1.0235	1.0240	1.0242	1.0244	1.0247	1.0248	1.0244	1.0242	1.0235	1.0241

APPENDIX 2

MEAN TEMPERATURE 1949 - 1953

Year	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
1949	80.5	80.0	79.9	81.6	80.0	79.6	78.5	79.5	80.2	79.2	80.1	78.9	79.8
1950	79.6	79.4	78.7	80.1	78.9	79.0	78.7	78.9	78.6	79.7	80.1	79.0	79.2
1951	79.8	80.5	80.8	80.9	79.9	79.6	77.3	78.5	78.9	79.2	80.1	80.9	79.7
1952	81.3	81.4	80.9	79.8	80.6	81.0	79.8	79.4	79.7	78.8	80.5	81.0	80.4
1953	81.4	81.0	81.8	81.6	79.7	80.2	79.5	77.6	77.8	80.3	80.3	81.0	80.2

MEAN MAXIMUM TEMPERATURE 1949 - 1953

Year	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
1949	86.9	86.5	86.6	88.0	86.6	86.0	84.8	88.5	86.7	85.7	87.0	85.5	86.6
1950	85.8	85.4	84.7	86.8	85.4	84.9	84.4	84.8	85.8	85.8	86.1	84.9	85.4
1951	85.1	86.7	86.0	87.1	86.3	85.5	85.2	84.8	85.0	85.0	85.5	86.9	85.8
1952	87.1	87.3	87.7	86.0	87.2	86.8	85.6	85.9	85.9	84.9	86.5	87.2	86.5
1953	87.4	86.5	87.8	88.5	86.2	86.3	84.7	83.9	84.9	85.8	86.4	87.0	86.3

MEAN MINIMUM TEMPERATURES 1949 - 1953

Year	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
1949	74.5	74.1	74.0	75.4	73.8	73.3	71.9	73.6	74.1	72.7	73.5	73.4	73.7
1950	73.9	73.6	73.6	73.6	73.0	73.1	72.6	72.5	71.8	73.6	74.2	73.6	73.3
1951	74.2	74.5	75.3	75.4	74.3	74.0	70.1	71.4	73.0	72.9	74.4	75.0	73.7
1952	75.6	75.1	74.5	74.1	74.3	74.7	73.7	72.5	72.6	72.7	73.8	75.0	74.1
1953	75.3	75.4	75.8	75.4	73.7	73.7	73.7	71.5	71.0	74.8	73.8	74.3	74.0

APPENDIX 3

MONTHLY RAINFALL - APIA OBSERVATORY - 1949 - 1953. (Unit-inches)

Date	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
1949	11.82	8.51	14.21	7.00	11.57	3.47	7.05	6.28	7.53	9.68	4.08	23.46	114.66
1950	17.74	21.58	27.38	8.16	15.54	11.73	5.89	4.54	4.34	8.02	6.37	33.78	165.07
1951	10.52	10.29	7.51	11.30	7.38	10.22	1.24	0.41	2.44	11.49	7.58	12.40	92.78
1952	11.73	11.93	13.11	12.71	6.90	4.74	2.10	1.68	5.34	7.49	1.69	9.92	89.34
1953	6.96	12.98	7.08	2.52	6.83	2.03	10.82	0.67	0.61	10.11	9.84	6.21	76.66

NUMBER OF RAIN DAYS PER MONTH 1949 - 1953

Date	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
1949	16	20	26	23	20	14	18	16	21	20	18	26	238
1950	21	25	27	22	22	23	19	21	13	20	22	30	265
1951	23	21	27	19	17	14	6	4	12	12	16	19	190
1952	22	17	21	17	16	19	13	13	9	22	9	22	200
1953	14	23	21	12	12	11	21	5	3	15	18	14	169

MEAN MONTHLY WIND SPEED FOR 1953. (Unit-knots)

Date	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
1953	5.27	3.92	3.02	2.31	4.19	7.39	10.19	7.90	5.95	7.40	6.01	3.47	5.58

PERCENTAGE FREQUENCY OF WIND FROM DIFFERENT DIRECTIONS 1953.

CALM	N.	NE.	E.	SE.	S.	SW.	W.	NW.
46	2	2	28	12	6	2	1	1

APPENDIX 4

DAILY SUNSHINE 1953

Date	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
1	8.0	4.4	0.9	9.2	9.5	9.5	0.3	5.3	8.5	11.0	8.8	10.0
2	8.6	6.7	4.6	8.6	9.4	10.1	9.0	5.2	9.2	10.2	2.7	9.7
3	4.9	10.2	10.6	9.6	11.2	8.0	0.0	0.5	9.8	8.3	3.9	12.1
4	6.0	11.6	7.2	0.8	11.2	4.6	8.0	5.4	10.6	5.0	0.0	7.6
5	9.6	11.7	10.4	8.3	11.2	8.8	5.5	5.2	10.5	6.7	4.0	9.8
6	11.6	11.5	8.7	9.7	7.8	9.0	7.3	3.8	6.2	6.6	2.0	9.7
7	1.8	11.2	8.6	10.7	10.2	3.7	10.2	0.0	0.8	11.2	2.4	6.9
8	0.0	2.1	8.7	9.9	10.8	6.5	7.2	7.9	0.1	10.9	7.2	4.3
9	2.4	5.9	11.7	10.6	10.2	3.0	10.6	1.9	6.7	10.9	11.2	4.1
10	9.9	1.2	8.1	8.3	10.4	6.4	7.9	1.9	11.0	2.0	6.3	4.5
11	4.4	8.0	9.7	5.3	10.6	0.9	4.3	5.5	9.7	10.8	8.6	8.2
12	8.5	0.8	10.9	3.5	8.7	10.5	6.0	10.2	8.8	10.0	10.4	11.0
13	11.4	0.0	8.3	2.0	4.8	7.8	8.6	8.0	9.4	5.3	9.6	11.7
14	12.0	0.2	6.5	3.8	2.8	6.3	10.0	10.6	8.1	2.0	11.0	7.5
15	11.9	3.5	8.3	10.2	4.4	9.7	9.1	10.3	3.2	7.4	9.8	8.9
16	12.4	10.2	3.4	9.0	7.8	6.7	6.8	8.0	8.6	3.2	10.9	10.0
17	11.3	4.9	7.5	8.1	0.7	9.3	8.4	9.7	7.3	0.0	8.7	1.7
18	10.9	7.5	6.7	8.7	3.2	10.3	0.0	8.3	8.5	2.0	11.2	0.0
19	2.8	1.4	9.7	11.1	0.0	10.5	10.4	5.6	9.3	0.0	9.2	2.4
20	11.1	3.9	7.4	6.2	7.8	9.6	10.3	8.5	2.4	6.4	2.8	6.7
21	10.4	8.8	6.8	8.5	0.7	10.2	0.3	10.3	8.4	8.7	5.2	7.7
22	8.3	9.4	9.3	7.7	8.4	10.4	7.2	8.4	6.1	10.7	0.5	9.3
23	8.2	10.7	2.6	8.8	3.3	10.5	7.4	9.7	8.6	11.2	6.0	9.3
24	4.6	6.0	0.1	7.6	6.3	7.6	4.8	8.7	10.1	12.1	0.2	11.3
25	3.8	5.3	0.0	7.2	6.0	8.7	1.7	8.5	11.2	9.8	7.9	11.3
26	2.9	4.0	0.7	7.8	8.4	10.4	4.1	9.0	10.5	9.1	5.6	10.1
27	10.4	8.8	8.0	4.6	10.6	9.4	4.8	9.9	10.7	7.5	5.3	10.2
28	11.6	10.0	10.6	6.6	10.4	9.3	6.0	4.0	11.3	1.2	3.8	8.2
29	10.4		9.4	10.1	0.1	7.0	8.9	10.6	11.1	0.0	8.3	8.7
30	10.7		5.0	7.4	8.9	8.0	6.8	7.5	11.2	2.7	8.7	9.0
31	8.3		6.4		7.6		1.0	6.3		8.1		10.9
Total	249.1	179.9	216.8	229.9	223.4	242.5	192.9	214.7	247.9	210.7	192.4	252.8
Mean	8.0	6.4	7.0	7.7	7.2	8.1	6.2	6.9	8.3	6.8	6.4	8.2

Total for year 2653.0

Mean daily total 7.3

APPENDIX 5

RISE AND FALL OF THE TIDE

Springtide: 3'6" - 4'3"

Neaptide: 1'8" - 2'

The tide is a double one, in other words, it is full twice in the space of 24 hours, 50 minutes.

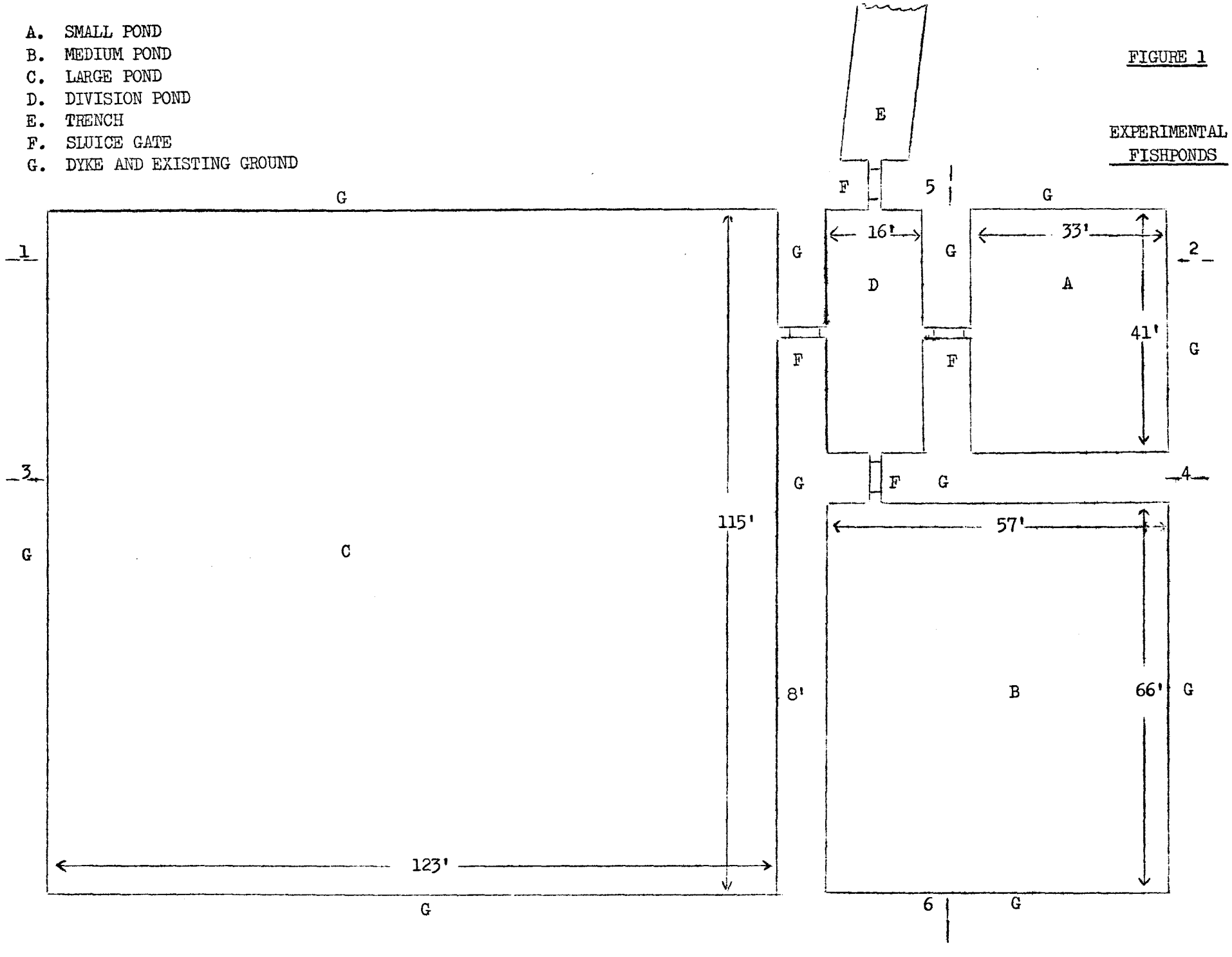
RESULTS OF ANALYSIS OF WATER SAMPLES

Place	Density	p.H	Chlorides (parts in 1000,000 parts H_2O)
Near future pond	1.010	7.5	787
Tidal creek (surface)	1.012	8.5	1128
Tidal creek (1 foot deep)	1.014	8.5	1163

A. SMALL POND
B. MEDIUM POND
C. LARGE POND
D. DIVISION POND
E. TRENCH
F. SLUICE GATE
G. DYKE AND EXISTING GROUND

FIGURE 1

EXPERIMENTAL FISHPONDS



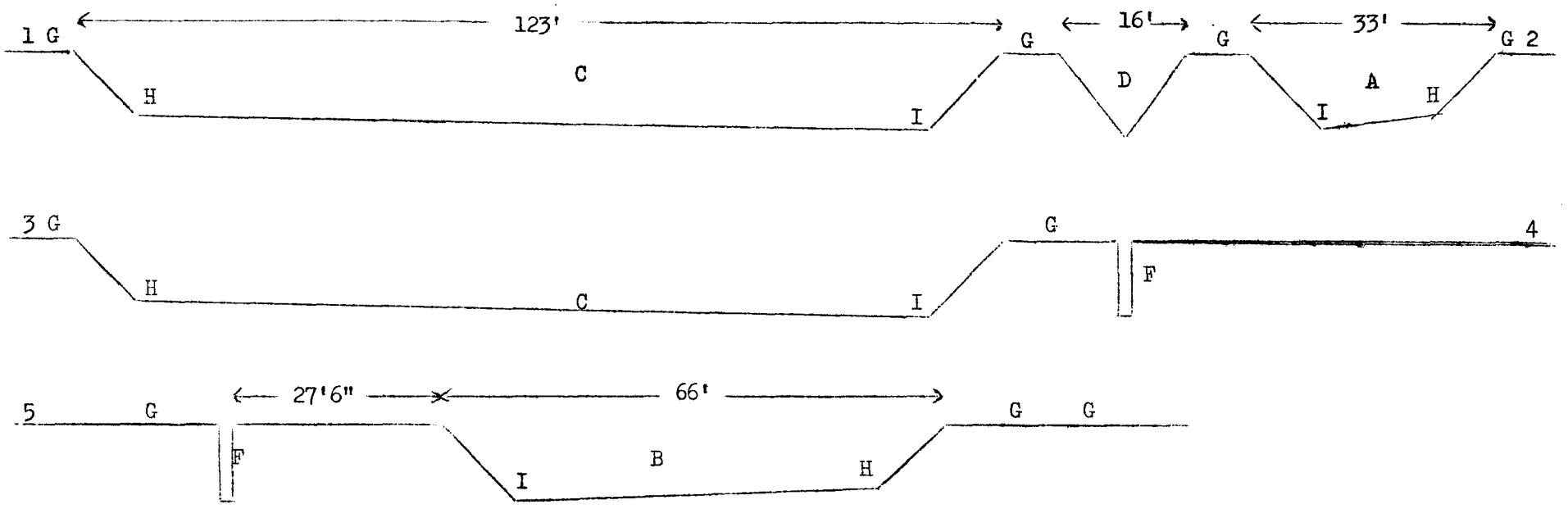
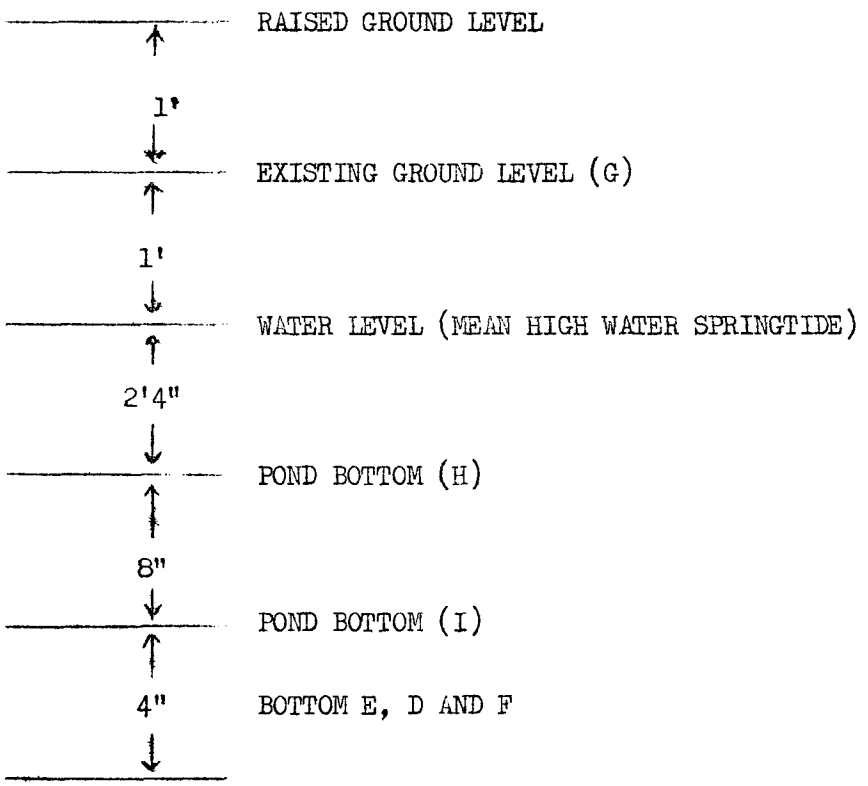
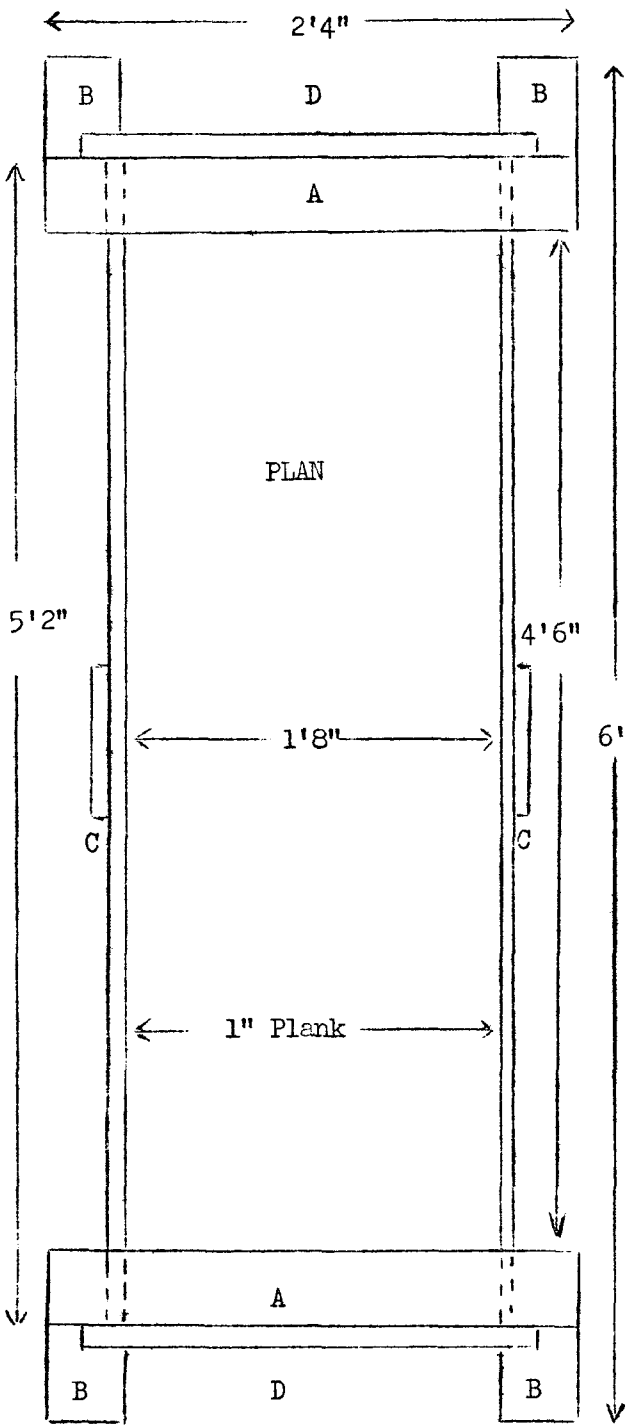
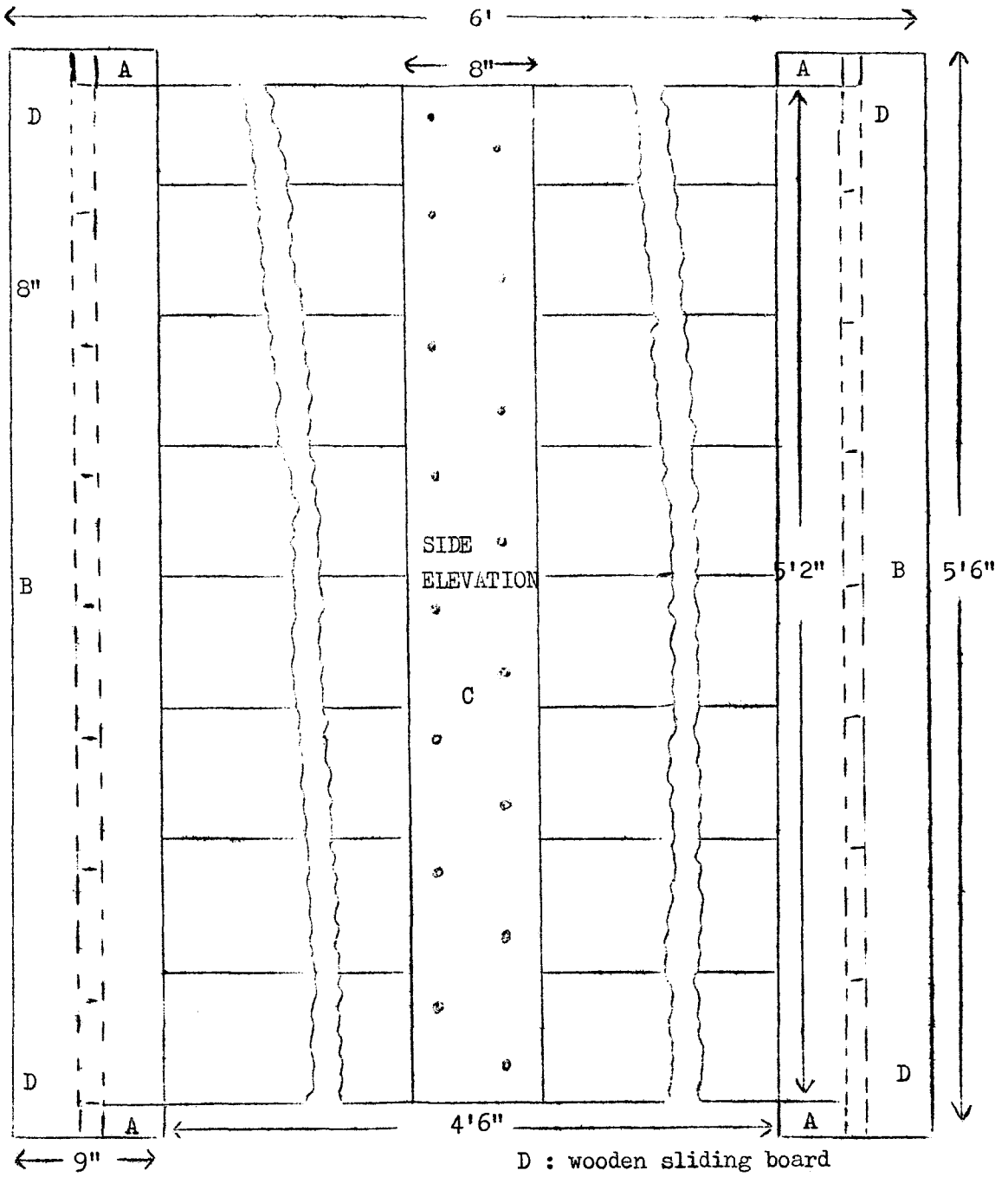


FIGURE 2

PROFILES OF FISHPONDS SHOWN IN FIGURE 1 AND LEVELS







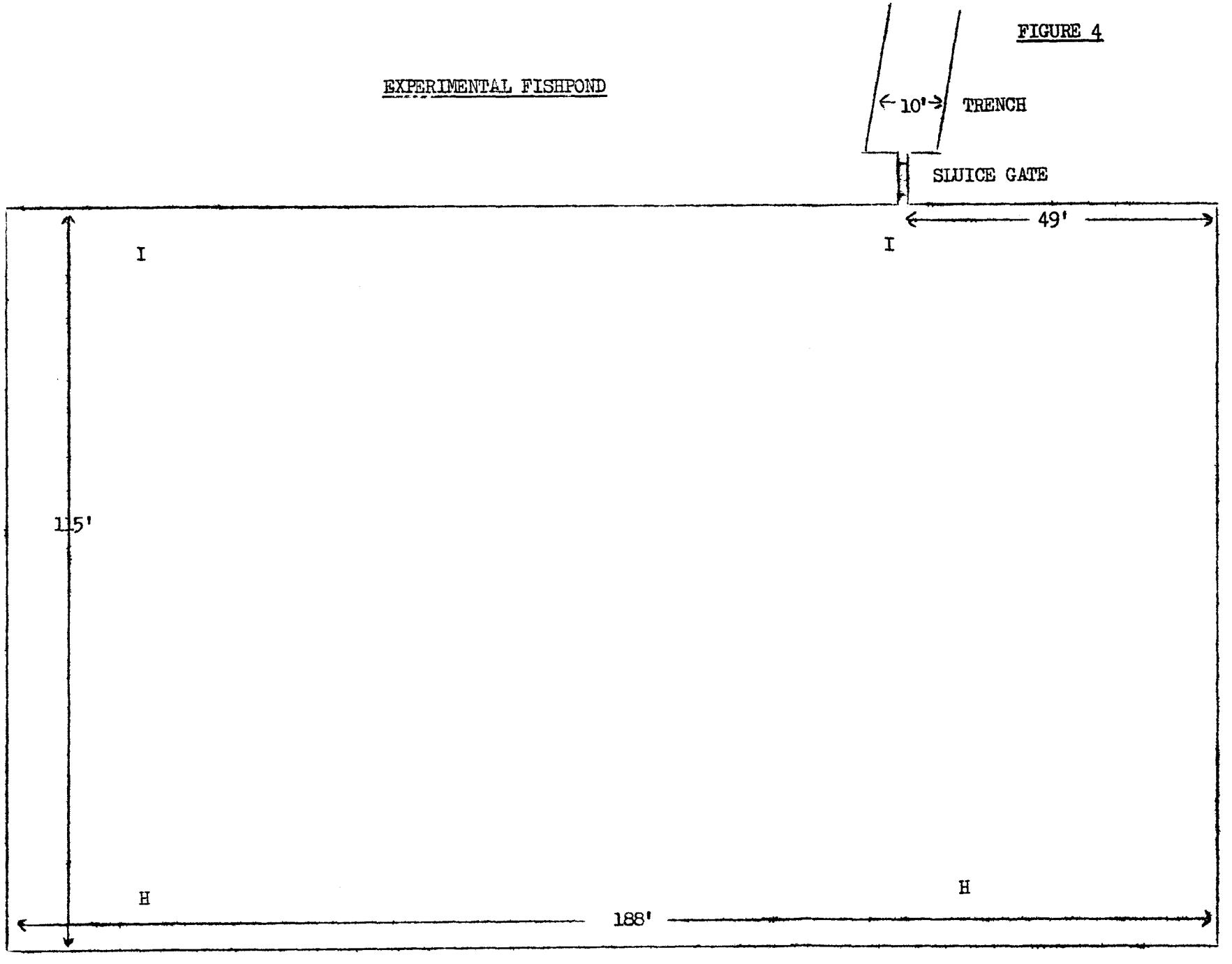
D : wooden sliding board

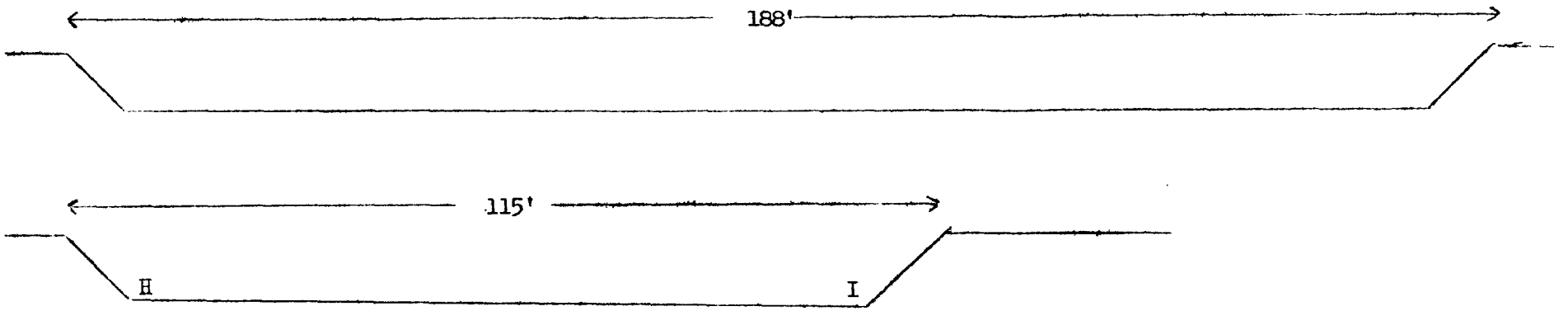
WOODEN SLUICE GATE

FIGURE 3

FIGURE 4

EXPERIMENTAL FISHPOND





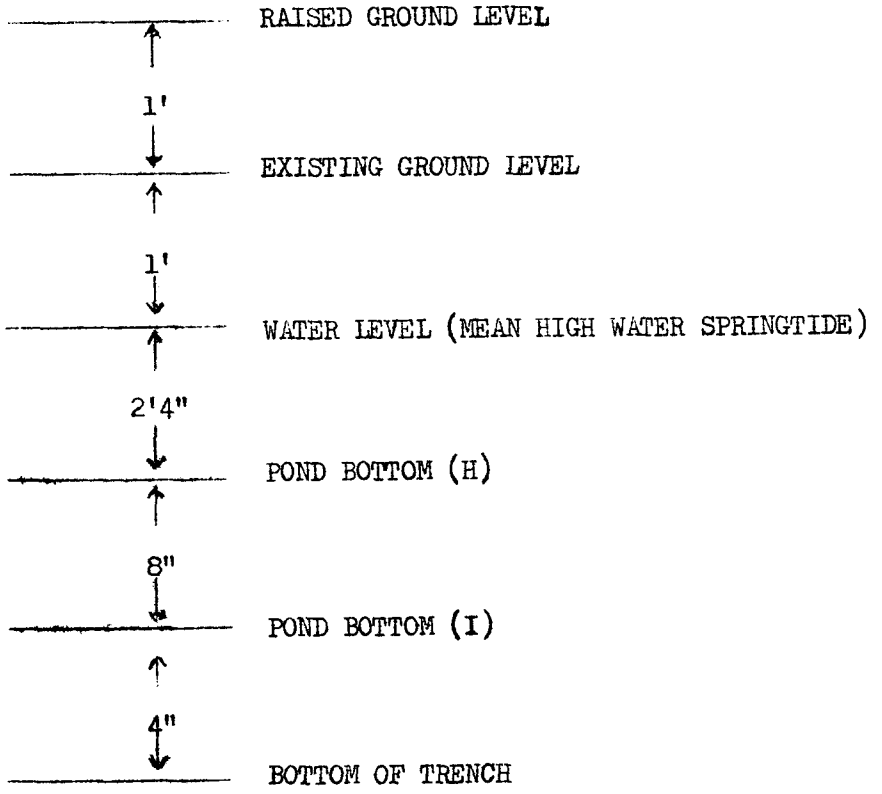
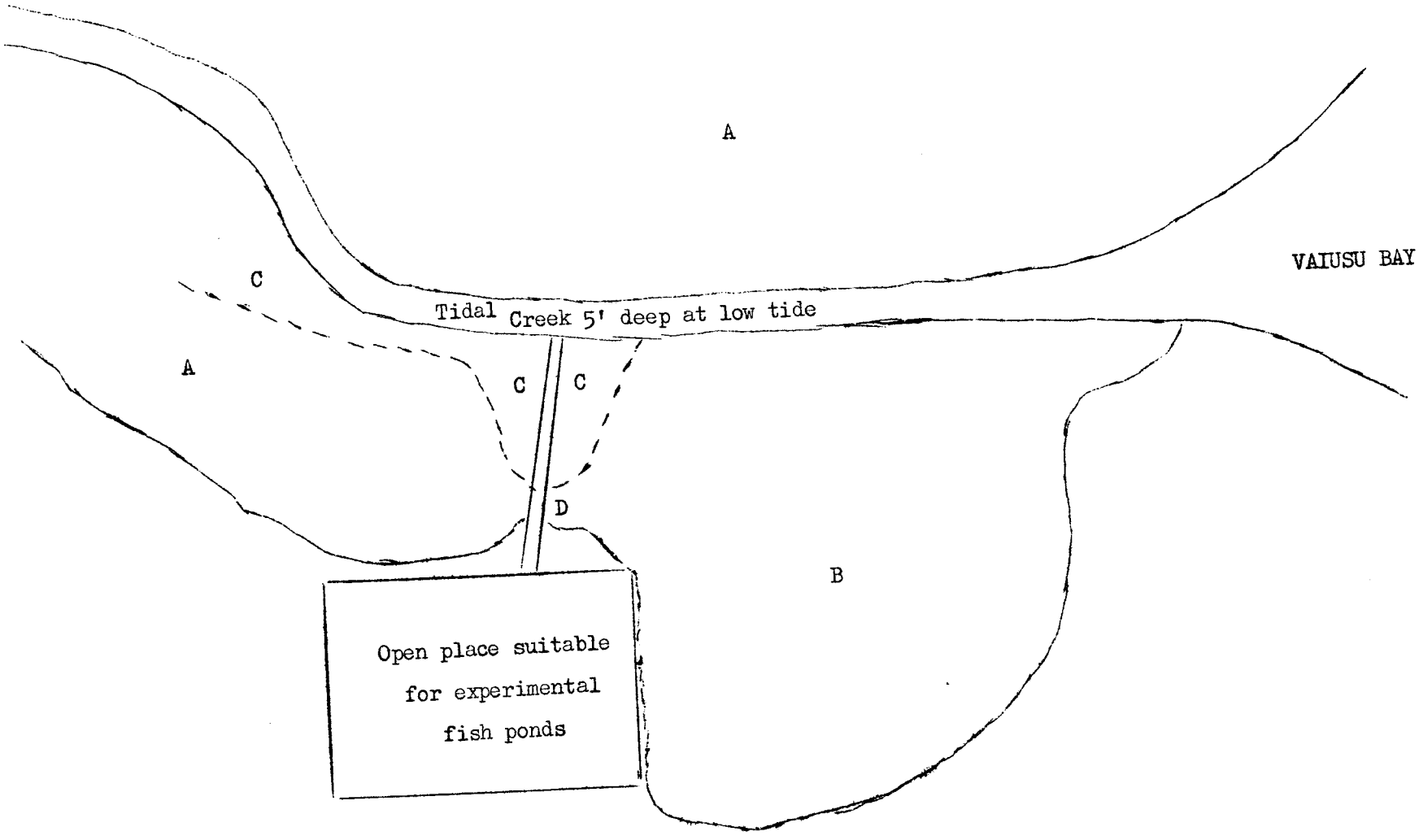


FIGURE 5

PROFILE OF FISHPO
SHOWN IN FIGURE 4

FIGURE 6

PROPOSED SITE OF EXPERIMENTAL PONDS AT SOGI



A. MANGROVE
B. MANGROVE & OTHER LOW TREES
C. HIGH WATER MARK
D. TRENCH