A SANITARY SURVEY OF A GROUP OF SWIMMING POOLS USING DECHLORINATED SAMPLES

THESIS FOR THE DEGREE OF B. S.

Herbert J. Dunsmore

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THESIS

Swimming pools - Sanitation

A Sanitary Survey of a Group of Swimming Pools Using Dechlorinated Samples

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INTRODUCTION

The sanitary quality and methods of measuring the same has not kept pace with the popularity and increase of installations of swimming pools. True, sanitarians have developed methods of measurements and engineers have perfected methods of purifications, but in the light of recent investigations, these have proved inadequate. Dilutions by a circulation process of passing the used water through a sand filter have failed to maintain a satisfactory water. Chemical treatment following filtration appeared necessary. One ofthe first disinfectants used was ozone, followed shortlyby ultra-violet ray. Both of these produced a sterile water, but unfortunately they do not impart to the water any residual germicidal properties to maintain sterility. It has been demonstrated repeatedly that dilutionsthrough the introdution of sterile water is not an adequate means of maintaining purity in swimming pools. It is necessary that the water in the pool has a residual germicidal property to destroy the bacteria as they are voided from the bathers. It is possible to maintain sucha condition with chlorine when introduced either as liquid chlorine or hypo-chloride. Prior to the use of liquid chlorine calcium hypo-chlorine was used, but with mediocre success, due to the crude methods of application. Also, no method of measuring the resulting residual chlorine existed, so the only check on the effective amounts was a bacteriological test, the results of which were obtained forty-eight hours after the collection of the samples. This delay, of course, was so great that it had no value as far as the immediate application was concerned. Parallel with the introduction of liquid chlorine and dependable methods of measuring, the ortho-tolidine test was developed.

The ortho-tolidine is a simple and easy test to perform. Take a 10 c.c. portion of the pool water, and mix 1 c.c. of ortho-tolidine. If there is any chlorine in the water it will turn yellow or amber color. Then this mixture is compared with a set of standards that have been previously made up to a known chlorine content. When using a Hellige comparator such as was used in this work the standards are stained glass, which are stained to give a known chlorine content. Then the mixture is placed into the apparatus and the disc, on which the stained glass is fixed, is turned until the two colors coincide and one can read the residual chlorine directly.

Apparently, the pollution of swimming pools had been solved, and for several years sanitarians congratulated themselves on the results obtained. Pools were maintained in sterile condition for years.

A residual chlorine of 0.2 to 0.5 P.P.M. had rendered the water sterile, and the water was considered equal to the treasury method standard for drinking water.

In a study of pool conditions by Mallmann and Cary it was necessary to perform pool side testing. They found that such samples tested immediately during periods of heavy bathing load were heavily polluted, whereas, similar samples carried to the laboratory and tested several hours after collection, were sterile. The delayed action of residual chlorine by this time had killed all the remaining organisms.

Mallmann suggested the use of sodium thiosulphate to be used in the collection of samples. A few crystals of sodium thiosulphate are placed in the bottles before samples are taken. This takes out the effective chlorine immediately on the collection of the sample. The sodium thiosulphate acts as a reducing agent.

From the experiment that was carried on by Mallmann and Cary showed that the pollution in the swimming pool reached its peak at about five minutes after the bathers had entered the water. They found that this pollution changed during the period that the bathers were using the pool. Also, that the pool sterilized itself very rapidly after the swimmers got out of the water, providing that there was a residual chlorine of 0.2 P.P.M. or more. This showed that there is a need of sampling water during the period that the pool is loaded. They found that the pools contained high total counts with a heavy bathing load and low amounts of chlorine, and that the pollution was from esch. coli and streptococcus. There seemed to be a marked increase in streptococcus over coli. Therefore, they suggested the need of a new standard for index of pollution for swimming pools, that is, to replace the esch. coli index which is now the index with a streptococcus index. Of course, this new standard cannot be as rigid as the coli standard is. More data will have to be obtained before a standard can be made.

The problem of this thesis is to strengthen the data above; to give more information from which the writer hopes to arrive at some accurate conclusions; to compare methods of chlorinations; and to study bathing loads in relation to pollution.

EXPERIMENTAL

This survey was conducted on five high school pools, three junior and two senior. Thecollege pool was used as a control. Samples were taken four days a week for a period of four weeks. Two samples were taken each time, one on each side of the pool. The residual chlorine was checked by the ortho-tolidine method each time a sample was taken using the Hillige comparator.

Cultures were made by adding 10 c.c. of the samples to a Durham fermentation tubee containing approximately 10 c. c. of double strength lactose broth. The tubes were incubated at 37^{o} C. for forty-eight hours. Five tubes were made from each sample. Also, two 1 c.c. portions of the sample were plated using plain agar and incubated at 37^{o} C. for forty-eight hours. The readings were made at the end of twenty-four and forty-eight hours. Tubes showing gas production were checked for escherichia coli by smearing on eosin methyline blue agar plates. The tubes showing growth indicating streptococcus were confirmed microscopically. The total count was recorded after twenty-four and forty-eight hours of incubation.

DATA

These are all indoor pools of the circulating type using pressure filters. The five high school pools have the same kind of home-made chlorinator. Each pool is cleaned several times a week with a vacuum cleaner which cleans the bottom and sides. Then the water is allowed to run over into the scum gutters once or twice a week. The pools are emptied three or four times a year and are filled with fresh water. The college pool has a Paradon type of chlorinator. The pools are all operated under practically the same regulations. The bathers have to take showers and use soap liberally. They are then inspected by the instructor before entering the pool. The girls are required to wear a light, grey cotton suit while using the pool and in all cases the boys use the pool in the nude. The only noticeable difference between the girls and boys using the pool is that the girls seem to pull the chlorine out of the water faster. This is probably due to the cotton suits they wear.

The pools will be designated by the letters A., B., C., D., E., and F. in this thesis.

Pool A. was installed in 1928. It has a capacity of 85,000 gallons, and an average daily bathing load of 125. It has a centrifugal pump with a 2½" discharge, a rate of 225 gallons per minute, and a turn over of eight hours. The pump is in operation 18 hours daily. It has three 5' International pressure filters using alum as a coagulant, and a hair catcher in the line to remove any material that would plug the filters. The temperature of the water in the pool ranges from 75° to 80° F. and the temperature of air in the pool room is about 82° F. This pool has very good natural light and good ventilation. The water is about 8½' deep at the deep end and 3½' deep at the shallow end. The pool is 25' wide and 75' long with a 6' walk around the pool. It has two inlets, one on each end, and the outlet is through a drain located at the deep end of the pool.

Pool B. was installed in 1922. It has a capacity of 65,475 gallons and an average daily bathing load of 240. It has a centrifugal pump with a 2½" discharge, a rate of 225 gallons per minute, and a turn over of six hours. The pump is in operation about 20½ hours daily. It has two 4½' Jewell pressure filters using alum as a coagulant, and a hair catcher in the line to remove any material that would plug the filters. The temperature of the water in the pool ranges from 71° to 75° F. and the temperature of air in the pool room is about 76° F. This pool has

little natural light and fair ventilation. The water is about 8' deep at the deep end and about 3½' deep at the shallow end. The pool is 24' wide and 60' long with a 7' walk around the pool. There is a scum gutter on all four sides. It has two inlets at shallow end and outlets at the deep end of the pool.

Pool C. was installed in 1928. It has a capacity of 36,750 gallons, and an average bathing load of 150. It has a centrifugal pump with a 1½" discharge, a rate of 150 gallons per minue, and a turn over of 5¼ hours. The pump is in operation about twenty hours daily. It has one 5' pressure filter using alum as a coagulant, and a hair catcher in the line to remove any material that would plug the filters. The temperature of the water in the pool ranges from 74° to 76° F. and the temperature of air in the pool room is about 78° F. This pool has practically no natural light and no ventilation. The water is about 7½' deep at the deep end and 2½' at the shallow end. The pool is 20' wide and 48½' long with a 4' walk around the pool. There is a scum gutter on all four sides. It has four inlets along one side of the pool and four outlets along the other side of the pool.

water is about 10' deep at the deep end and 3½' deep at the shallow end. The pool is 30' wide and 90' long with a 10' walk around the pool. There is a scum gutter on all four sides. It has six inlets, three on each end and the outlet is through a drain located at the deep end of the pool.

DATA ARRANGED AS TO INDIVIDUAL POOLS

Source	No.	Bath Load	Resid-uary Cl_2 in P.P.M.	Esh. Coli	Strep-tococcus	48 Hr. Count	24 Hr. Count
A	53	10M	0.8	-----	-----	0	0
	54	10M	0.8	-----	--ppp	0	0
	63	5F	0.4	-----	-----	30	2
	64	5F	0.4	-----	-----	27	2
	75	7M	0.4	-----	ppps-	--	--
	76	7M	0.4	-----	sspss	--	--
	88	8F	0.4	-aa--	-p---	0	0
	89	8F	0.4	-----	-----	0	0
	100	12F	0.4	-----	-----	126	0
	101	12F	0.4	-----	ps---	107	0
	112	14M	0.4	-----	-s---	6	6
	113	14M	0.4	-----	-----	0	0
	124	10F	0.3	-----	p----	0	0
	125	10F	0.3	-----	p----	0	0
	136	15M	0.3	-----	pp---	309	0
	137	15M	0.3	-----	spppp	117	0
	148	7F	0.3	-----	-----	0	0
	149	7F	0.3	-----	s----	0	0
	160	4M	0.0	-----	spssp	117	0
	161	4M	0.0	-----	psppp	98	0
	172	12M	0.3	-----	-----	0	0
	173	12M	0.3	-----	-----	0	0
	184	12M	0.15	-----	ppps-	0	0
	185	12M	0.15	-----	ppppp	0	0
	196	7F	0.4	-----	-----	102	0
	197	7F	0.4	-----	pppp-	87	0
	218	9F	0.4	-----	s----	0	0
	219	9F	0.4	-----	-----	0	0
	230	7M	0.3	-----	-----	230	0
	231	7M	0.3	-----	-----	217	0
B	55	15F	1.5	-----	-----	0	0
	56	15F	1.5	-----	-----	5	2
	65	24F	0.8	-----	-----	9	4
	66	24F	0.8	-----	--ppp	42	30
	77	11F	1.0	-----	-----	--	--
	78	11F	1.0	-----	ppp--	--	--
	90	35M	0.5	-----	p-s--	327	256
	91	35M	0.5	-----	--sp-	816	621

Source	No.	Bath Load	Residuary cl_2 in P.P.M.	Esh. Coli	Streptococcus	48 Hr. Count	24 Hr. Count.
B	102	8M	2.4	-----	-----	0	0
	103	8M	2.4	-----	-----	0	0
	114	25F	0.6	-----	-----	0	0
	115	25F	0.6	-----	-----	0	0
	126	20F	0.4	-----	-pppp	1601	411
	127	20F	0.4	-----	-ssss	709	327
	138	11M	0.3	-----	ppppp	16113	10147
	139	11M	0.3	-----	-----	14097	13172
	150	35M	0.4	appa-	pppp-	4692	178
	151	35M	0.4	-a-aa	ppppp	1231	98
	162	25F	0.0	a-p--	ppppp	542	311
	163	25F	0.0	a----	p-pps	1043	523
	174	21F	0.3	p-p--	ppp--	112	48
	175	21F	0.3	-p---	pp---	87	39
	186	10F	0.8	-----	p----	0	0
	187	10F	0.8	-----	-----	0	0
	198	37M	0.5	-----	---p-	246	30
	199	37M	0.5	a-aaa	p-pss	198	27
	208	20F	1.5	-----	s----	0	0
	209	20F	1.5	-----	-----	0	0
	220	15F	0.2	-----	s----	26	22
	221	15F	0.2	-----	-----	31	17
	234	12F	0.5	-----	-----	406	83
	235	12F	0.5	-----	-----	905	128
C	57	10F	0.6	-----	-----	20	15
	58	10F	0.6	-----	-----	0	0
	67	12M	0.3	-----	p-spp	187	1
	68	12M	0.3	-----	p-ppp	173	6
	78	8F	0.1	-----	ppppp	--	Viridian
	79	8F	0.1	-----	ppppp	--	Viridian
	92	17M	0.2	apppp	spppp	1683	1272
	93	17M	0.2	pp-pp	sp-pp	1723	1293
	104	12M	0.6	-----	sppsp	5	0
	105	12M	0.6	-----	-pp--	3	0
	116	7F	0.2	-----	sppps	20	3
	117	7F	0.2	-----	ppppp	4	0
	128	0	2.plus	-----	p----	0	0
	129	0	2.plus	-----	s----	0	0
	140	11F	1.0	-----	-----	0	0
	141	11F	1.0	-----	pp---	0	0
	152	25M	1.0	-----	-----	0	0

Source	No.	Bath Load	Residuary Cl_2 in P.P.M.	Esh. Coli	Streptococcus	48 Hr. Count	24 Hr. Count
C	153	25M	1.0	-----	-----	0	0
	164	9F	0.8	-----	p----	0	0
	165	9F	0.8	-----	pss-p	0	0
	176	18M	0.7	-----	pp---	0	0
	177	18M	0.7	-----	pps--	0	0
	188	8F	0.4	-----	ppp--	0	0
	189	8F	0.4	-----	ppp--	0	0
	200	12M	0.3	p-p-p	pp---	146	123
	201	12M	0.3	a----	pp---	202	176
	210	8F	0.5	-----	-----	0	0
	211	8F	0.5	-----	sspps	0	0
	222	16M	2.0	-----	-----	0	0
	223	16M	2.0	-----	-----	0	0
	236	12F	1.0	-----	-----	0	0
	237	12F	1.0	-----	-----	0	0
D							
	59	12F	0.6	-?--?	ppppp	7418	4200
	60	12F	0.6	-----	ppppp	5600	3600
	69	10F	0.1	-----	ppppp	25000	20000
	70	10F	0.1	-----	ppspp	31000	22000
	80	17F	0.4	-----	sssss	--	--
	81	17F	0.4	-----	p----	--	--
	94	40M	0.4	--a--	pp-s-	39	20
	95	40M	0.4	-----	pp-pp	51	33
	106	8M	0.5	-----	-----	0	0
	107	8M	0.5	-----	-----	5	0
	118	8F	0.5	-----	ppp--	31	27
	119	8F	0.5	-----	-pp--	28	19
	130	21F	1.5	-----	ssp--	0	0
	131	21F	1.5	-----	sp---	0	0
	142	20F	0.7	-----	-----	0	0
	143	20F	0.7	-----	-----	20	0
	154	35M	0.3	-----	ppppp	93	53
	155	35M	0.3	-----	ppppp	122	27
	166	13F	2.0	-----	-----	0	0
	167	13F	2.0	-----	-----	0	0
	178	30F	0.6	-----	s----	33	0
	179	30F	0.6	-----	ppppp	40	0
	190	8F	0.8	-----	pp---	0	0
	191	8F	0.8	-----	pp---	0	0
	202	30M	0.4	-p---	ppppp	26	15
	203	30M	0.4	--pp-	ppppp	88	47

Source	No.	Bath Load	Resid-uary Cl_2 in P.P.M.	Esh. Coli	Strep-tococcus	48 Hr. Count	24 Hr. Count
D	212	18F	1.7	-----	-----	0	0
	213	18F	1.7	-----	-----	0	0
	224	12F	0.5	-----	ssss-	37	4
	225	12F	0.5	-----	-pspp	26	10
	238	14F	2.0	-----	-----	0	0
	239	14F	2.0	-----	-----	0	0
E	61	7M	0.4	---p-	ppppp	208	147
	62	7M	0.4	----?	ppppp	310	47
	71	40F	0.1	----p	ppppp	57000	51000
	72	40F	0.1	p--p-	ppppp	60000	47000
	82	30M	0.0	-----	ppppp	--	--
	83	30M	0.0	-----	ppppp	--	--
	84	30M	0.0	--p--	ppppp	--	--
	85	30M	0.0	pp---	ppppp	--	--
	96	17M	0.8	-----	pppp-	0	0
	97	17M	0.8	----a	--s--	4	4
	108	20M	2.plus	-----	-----	0	0
	109	20M	2.plus	-----	-----	4	0
	120	37F	0.6	-----	sss--	0	0
	121	37F	0.6	-----	pppps	0	0
	132	48M	0.4	-----	ppppp	10647	6793
	133	48M	0.4	-----	ppp-p	16459	9491
	144	20M	0.05	-----	ppppp	17272	14562
	145	20M	0.05	-----	ppppp	21956	19956
	156	15M	0.9	-----	-----	0	0
	157	15M	0.9	-----	-----	0	0
	168	12F	0.3	-----	ppppp	641	197
	169	12F	0.3	-----	ppps-	709	247
	180	12F	0.6	-----	-----	0	0
	181	12F	0.6	-----	-----	0	0
	192	10M	0.15	-----	ppppp	790	417
	193	10M	0.15	-----	ppppp	467	283
	204	10M	0.2	-----	pppp-	92	69
	205	10M	0.2	-----	ssp--	122	107
	214	5F	0.05	-----	-pppp	542	226
	215	5F	0.05	--p--	pspss	411	298
	226	14F	0.8	-----	pp---	0	0
	227	14F	0.8	-----	-----	0	0
	240	12M	0.1	p---p	ppppp	7144	4562
	241	12M	0.1	----p	pps--	5651	3351

Source	No.	Bath Load	Resid-uary Cl_2 in P.P.M.	Esh. Coli	Strep-tococcus	48 Hr. Count	24 Hr. Count.
F	73	45M	0.5	-----	-ppps	47	20
	74	45M	0.5	-----	---p-	11	7
	86	2M	0.4	-----	-----	0	0
	87	2M	0.4	-----	-----	0	0
	98	10M	0.5	a----	s----	0	0
	99	10M	0.5	-----	--ss-	0	0
	110	8M	0.4	-----	-----	0	0
	111	8M	0.4	-----	-----	0	0
	122	9M	0.4	-----	ppp--	0	0
	123	9M	0.4	-----	-----	0	0
	134	45M	0.4	-----	ppppp	20	0
	135	45M	0.4	-----	--p--	4	0
	146	2M	0.5	-----	pppp-	0	0
	147	2M	0.5	-----	-----	0	0
	158	10M	0.5	-----	-----	0	0
	159	10M	0.5	-----	pps--	0	0
	170	0	0.5	-----	-----	0	0
	171	0	0.5	-----	-----	0	0
	182	0	0.5	-----	p----	0	0
	183	0	0.5	-----	-----	0	0
	194	7M	0.5	-----	-----	0	0
	195	7M	0.5	-----	-----	0	0
	206	7M	0.5	-----	p----	0	0
	207	7M	0.5	-----	-----	0	0
	216	0	0.5	-----	-----	0	0
	217	0	0.5	-----	-----	0	0
	228	40M	0.5	p--pp	ss-s-	0	0
	229	40M	0.5	-p---	ppss-	0	0
	242	1	0.5	-----	-----	0	0
	243	1	0.5	-----	-----	0	0

KEY TO DATA ON INDIVIDUAL POOLS:

In Esh. columns:

a ----- arogenies
p ----- confirmed esh. coli.
\- ----- no bubbles

In Streptococcus columns:

s ----- staphlococcus
p ----- confirmed streptococcus
\- ----- no growth

DATA ARRANGED WITH DECREASING AMOUNTS OF CHLORINE

Source	No.	Bath Load	Residuary Cl_2 in P.P.M.	Esh. Coli	Streptococcus	48 Hr. Count	24 Hr. Count.
B.	102	3M	2.plus	-----	-----	0	0
	103	3M	2.plus	-----	-----	0	0
C.							
	128	0	2.plus	-----	p----	0	0
	129	0	2.plus	-----	s----	0	0
	222	16M	2.plus	-----	-----	0	0
	223	16M	2.plus	-----	-----	0	0
D.	166	13F	2.plus	-----	-----	0	0
	167	13F	2.plus	-----	-----	0	0
	238	14F	2.plus	-----	-----	0	0
	239	14F	2.plus	-----	-----	0	0
E.	108	20M	2.plus	-----	-----	0	0
	109	20M	2.plus	-----	-----	4	0
D.	212	18F	1.7	-----	-----	0	0
	213	18F	1.7	-----	-----	0	0
B.	55	15F	1.5	-----	-----	0	0
	56	15F	1.5	-----	-----	5	2
	208	20F	1.5	-----	s----	0	0
	209	20F	1.5	-----	-----	0	0
D.	130	21F	1.5	-----	ssp--	0	0
	131	21F	1.5	-----	sp---	0	0
B.	77	11F	1.0	-----	-----	--	--
	78a	11F	1.0	-----	ppp--	--	--
C.	140	11F	1.0	-----	-----	0	0
	141	11F	1.0	-----	pp---	0	0
	152	25M	1.0	-----	-----	0	0
	153	25M	1.0	-----	-----	0	0
	236	12F	1.0	-----	-----	0	0
	237	12F	1.0	-----	-----	0	0
E.	156	15M	0.9	-----	-----	0	0
	157	15M	0.9	-----	-----	0	0

Source	No.	Bath Load	Residuary Cl_2 in P.P.M.	Esh. Coli	Streptococcus	48 Hr. Count	24 Hr. Count
A.	53	10M	0.8	-----	-----	0	0
	54	10M	0.8	-----	--ppp	0	0
B.	65	24F	0.8	-----	-----	9	4
	66	24F	0.8	-----	--ppp	42	30
	186	10F	0.8	-----	p----	0	0
	187	10F	0.8	-----	---p-	246	30
C.	164	9F	0.8	-----	p----	0	0
	165	9F	0.8	-----	pss-p	0	0
D.	190	8F	0.8	-----	pp---	0	0
	191	8F	0.8	-----	pp---	0	0
E.	97	17M	0.8	-----	pppp-	0	0
	97	17M	0.8	----a	--s--	4	4
	226	14F	0.8	-----	pp---	0	0
	227	14F	0.8	-----	-----	0	0
C.	176	18M	0.7	-p---	pp---	0	0
	177	18M	0.7	-----	pps--	0	0
D.	142	20F	0.7	-----	-----	0	0
	143	20F	0.7	-----	-----	20	0
B.	114	25F	0.6	-----	-----	0	0
	115	25F	0.6	-----	-----	0	0
C.	57	10F	0.6	-----	-----	20	15
	58	10F	0.6	----p	-----	0	0
	104	12M	0.6	p----	sppsp	5	0
	105	12M	0.6	ppp--	-pp--	3	0
D.	59	12F	0.6	pp-pp	ppppp	7418	4200
	60	12F	0.6	p----	ppppp	5600	3600
	178	30F	0.6	-----	s----	33	0
	179	30F	0.6	-----	ppppp	40	0
E.	120	37F	0.6	-----	sss--	0	0
	121	37F	0.6	-----	pppps	0	0
	180	12F	0.6	-----	-----	0	0
	181	12F	0.6	-----	-----	0	0

Source	No.	Bath Load	Residuary Cl_2 in P.P.M.	Esh. Coli	Streptococcus	48 Hr. Count	24 Hr. Count.
B.	90	35M	0.5	-----	p-s--	327	256
	91	35M	0.5	-----	--sp-	816	621
	198	37M	0.5	-----	---p-	246	30
	199	37M	0.5	a-aaa	p-pss	198	27
	234	12F	0.5	p----	-----	406	83
	235	12F	0.5	-----	-----	905	128
C.	210	8F	0.5	-----	-----	0	0
	211	8F	0.5	-----	sspps	0	0
D.	106	8M	0.5	-----	-----	9	0
	107	8M	0.5	-----	-----	5	0
	118	8F	0.5	-----	ppp--	31	27
	119	8F	0.5	pp---	-pp--	28	19
	224	12F	0.5	-----	ssss-	37	4
	225	12F	0.5	-----	-pspp	26	10
F.	73	45M	0.5	-----	-ppps	47	20
	74	45M	0.5	-----	---p-	11	7
	98	10M	0.5	ap---	s----	0	0
	99	10M	0.5	ppp--	--ss-	0	0
	146	2M	0.5	-----	pppp-	0	0
	147	2M	0.5	-----	-----	0	0
	158	10M	0.5	-----	-----	0	0
	159	10M	0.5	-----	pps--	0	0
	170	0	0.5	-----	-----	0	0
	171	0	0.5	-----	-----	0	0
	182	0	0.5	-----	p----	0	0
	183	0	0.5	-----	-----	0	0
	194	7M	0.5	-----	-----	0	0
	195	7M	0.5	-----	-----	0	0
	206	7M	0.5	-----	p----	0	0
	207	7M	0.5	-----	-----	0	0
	216	0	0.5	-----	-----	0	0
	217	0	0.5	-----	-----	0	0
	228	40M	0.5	p--pp	ss-s-	0	0
	229	40M	0.5	-p---	ppss-	0	0
	242	1	0.5	-----	-----	0	0
	243	1	0.5	-----	-----	0	0

Source	No.	Bath Load	Residuary Cl2 in P.P.M.	Esh. Coli	Streptococcus	48 Hr. Count.	24 hr. Count.
A.	63	5F	0.4	-----	-----	30	2
	64	5F	0.4	-----	-----	27	2
	75	7M	0.4	-----	ppps-	--	--
	76	7M	0.4	-----	ssPss	--	--
	88	8F	0.4	-pp--	-p---	0	0
	89	8F	0.4	-----	-----	0	0
	100	12F	0.4	-----	-----	126	0
	101	12F	0.4	-----	ps---	107	0
	112	14M	0.4	p----	-s---	6	6
	113	14M	0.4	-----	-----	0	0
A.1	196	7F	0.4	-----	-----	102	0
	197	7F	0.4	-----	pppp-	87	0
	218	9F	0.4	-----	s----	0	0
	219	9F	0.4	-----	-----	0	0
B.1	126	20F	0.4	-----	-pppp	1601	411
	127	20F	0.4	-----	-ssss	709	327
	150	35M	0.4	appa-	pppp-	4692	178
	151	35M	0.4	-a-aa	ppppp	1231	98
C-1	188	8F	0.4	-----	ppp--	0	0
	189	8F	0.4	-----	ppp--	0	0
D-1	80	17F	0.4	-----	sssss	--	--
	81	17F	0.4	-----	p----	--	--
	94	40M	0.4	--a--	pp-s-	39	20
	95	40M	0.4	-----	pp-pp	51	33
	202	30M	0.4	-p---	ppppp	26	15
	203	30M	0.4	--pp-	ppppp	88	47
E-1	61	7M	0.4	---pp	ppppp	208	147
	62	7M	0.4	----p	ppppp	310	47
	132	48M	0.4	pp-pp	ppppp	10647	6793
	133	48M	0.4	pp--p	ppp-p	16459	9491
F-1	110	8M	0.4	-----	-----	0	0
	111	8M	0.4	-----	-----	0	0
	122	9M	0.4	-----	ppp--	0	0
	123	9M	0.4	-----	-----	0	0
	134	45M	0.4	-----	ppppp	20	0
	135	45M	0.4	-----	--p--	4	0

Source	No.	Bath Load	Residuary Cl_2 in P.P.M.	Esh. Coli	Streptococcus	48 Hr. Count	24 hr. Count.
F-1	86	2M	0.4	-----	-----	0	0
	87	2M	0.4	-----	-----	0	0
A-1	124	10F	0.3	-----	p----	0	0
	125	10F	0.3	-----	p----	0	0
	136	15M	0.3	ppppp	pp---	309	0
	137	15M	0.3	ppppp	spppp	117	0
	148	7F	0.3	-----	-----	0	0
	149	7F	0.3	-----	s----	0	0
	172	12M	0.3	-----	-----	0	0
	173	12M	0.3	-----	-----	0	0
	230	7M	0.3	-----	-----	230	0
	231	7M	0.3	-----	-----	217	0
B-1	138	11M	0.3	p----	ppppp	16113	10147
	139	11M	0.3	-----	-----	14097	13172
	174	21F	0.3	p-ppp	ppp--	112	48
	175	21F	0.3	-p---	pp---	87	39
C-1	67	12M	0.3	p---p	p-spp	187	1
	68	12M	0.3	p-p-p	p-ppp	173	6
	200	12M	0.3	ppppp	pp---	146	123
	201	12M	0.3	apppp	pp---	202	176
D-1	154	35M	0.3	-----	ppppp	93	53
	155	35M	0.3	-----	ppppp	122	27
E-1	168	12F	0.3	ppp-p	ppppp	641	197
	169	12F	0.3	pp-pp	ppps-	709	247
B-1	220	15F	0.2	-----	s----	26	22
	221	15F	0.[illegible]	-----	-----	31	17
C-1	92	17M	0.2	apppp	spppp	1683	1272
	93	17M	0.2	ppppp	sp-pp	1723	1293
	116	7F	0.2	-----	sppps	20	3
	117	7F	0.2	-----	ppppp	4	0
E-1	204	10M	0.2	-----	pppp-	92	69
	205	10M	0.2	-----	ssp--	122	107

Source	No.	Bath Load	Resid-uary Cl_2 in P.P.M.	Esh. Coli	Strep-tococcus	48 Hr. Count.	24 Hr. Count.
A	184	12M	0.15	-----	ppps-	0	0
	185	12M	0.15	-----	ppppp	0	0
B-1	192	10M	0.15	p-p--	ppppp	790	417
	193	10M	0.15	pp-pp	ppppp	467	283
C-1	78	8F	0.1	ppppp	ppppp	--	Viridian
	79	8F	0.1	-----	ppppp	--	Viridian
D-1	69	10F	0.1	ppppp	ppppp	25000	20000
	70	10F	0.1	ppppp	ppspp	21000	22000
E-1	71	40F	0.1	ppppp	ppppp	57000	51000
	72	40F	0.1	ppppp	ppppp	60000	47000
	240	12M	0.1	pp-pp	ppppp	7144	4562
	241	12M	0.1	ppppp	pps--	5651	3351
	144	20M	0.05	ppppp	ppppp	17272	14562
	145	20M	0.05	ppppp	ppppp	21956	19956
	214	5F	0.05	pp-pp	-pppp	542	226
	215	5F	0.05	ppppp	pspss	411	298
A-1	160	4M	0.00	-----	spssp	117	0
	161	4M	0.00	-----	psppp	98	0
B-1	162	25F	0.00	appppp	ppppp	542	311
	163	25F	0.00	apppp	p-pps	1042	523
E-1	82	30M	0.00	ppppp	ppppp	60000	60000
	83	30M	0.00	ppppp	ppppp	60000	60000
	84	30M	0.00	ppppp	ppppp	60000	60000
	85	30M	0.00	ppppp	ppppp	60000	60000

KEY TO DATA ON DECREASING AMOUNTS OF CHLORINE:

In Esh. Columns:

a ----- arogenies
p ----- confirmed esh. coli.
- ----- no bubbles

In Streptococcus Columns:

s ----- staphlococcus
p ----- confirmed streptococcus
- ----- no growth

DISCUSSION

To avoid the expense of chlorinators, a devise was made as follows: the chlorine passes through a galvanized pipe, then through a rubber hose, a glass tube that is shunted off the return water line to the pool in such a manner that the bubbles of chlorine gas can be seen as they enter. Theoretically the number of bubbles of gas could be used as a measurement of the flow of chlorine into the sustem. The flow of gas is regulated by large gate valves located in the galvanized pipe line. At first only one valve was used, but due to the corrosiveness of the chlorine this valve leaked and finally three similar valves were placed in a series to act as a check on each other. The arrangement is very crude and cannot be regulated with any degree of accuracy due to the type of valve used. The result is that instead of a regular flow of bubbles through the glass tube a continuous flow may frequently occur with the result that the residual chlorine content of the pool may become too high. When this occurs the chlorinator is turned off and the residual chlorine may fall until there is practically no chlorine present. Serious pollution may then occur. In the case of excess chlorine marked irritation of the eyes of the swimmer may result.

The chlorine is applied to the pools on an average of once a day. If an excess occurs or the janitor forgets to add any more the pools go for several days before more chlorine is added. More than a few times during this survey the writer found that no chlorine had been added to the water for a period of two or three days at a time.

The chlorinator used at pool F. or the control pool, is a very simple and easily operated devise. It consists essentially of silver tubing with a silver needle valve for adjusting the amounts of chlorine. The gas is passed through a glass section so the operator can tell the amount that is being released. There is a pressure gage on the tank so one can tell when the tank is empty. A device of this kind, although the initial cost is much greater than that of the home made type, is cheaper in the end due to the amount of chlorine one is able to save. When the chlorine is injected into a pool until the content is 2. P.P.M. or more much of the gas escapes into the air, and is wasted as far as disinfecting the pool. Also, it is very irritating to the swimmers. With a chlorinator such as the one which is in use at Pool F. one can maintain an even amount of residual chlorine if care is taken in operating the pool. The chlorinator used in Pool F. is operated continually, and the amount is varied with the bathing load, which tends to keep the residual at a constant amount.

The chemistry connected with the use of chlorine in swimming pools is rather certain, and can be expressed as follows: When chlorine is added to water it reacts thus: 2Cl plus H_2O equals HOCL plus HCL. Then the hypochlorous acid unites with the basic salts of the water, for example, HOCL plus NA_2CO_3 equals NAOCL plus H_2O. The sodium hypo-chlorite being very unstable combines with the water as NAOCL plus H_2O equals HOCL plus NAOH. The hypochlorous acid (HOCL) of this reaction being unstable breaks down as in equation HOCL equals HCL plus O giving off nascent oxygen. This nascent oxygen is the important element in the reactions. It is this nascent oxygen that oxydizes the bacteria, and makes chlorine a good disinfectant in water.

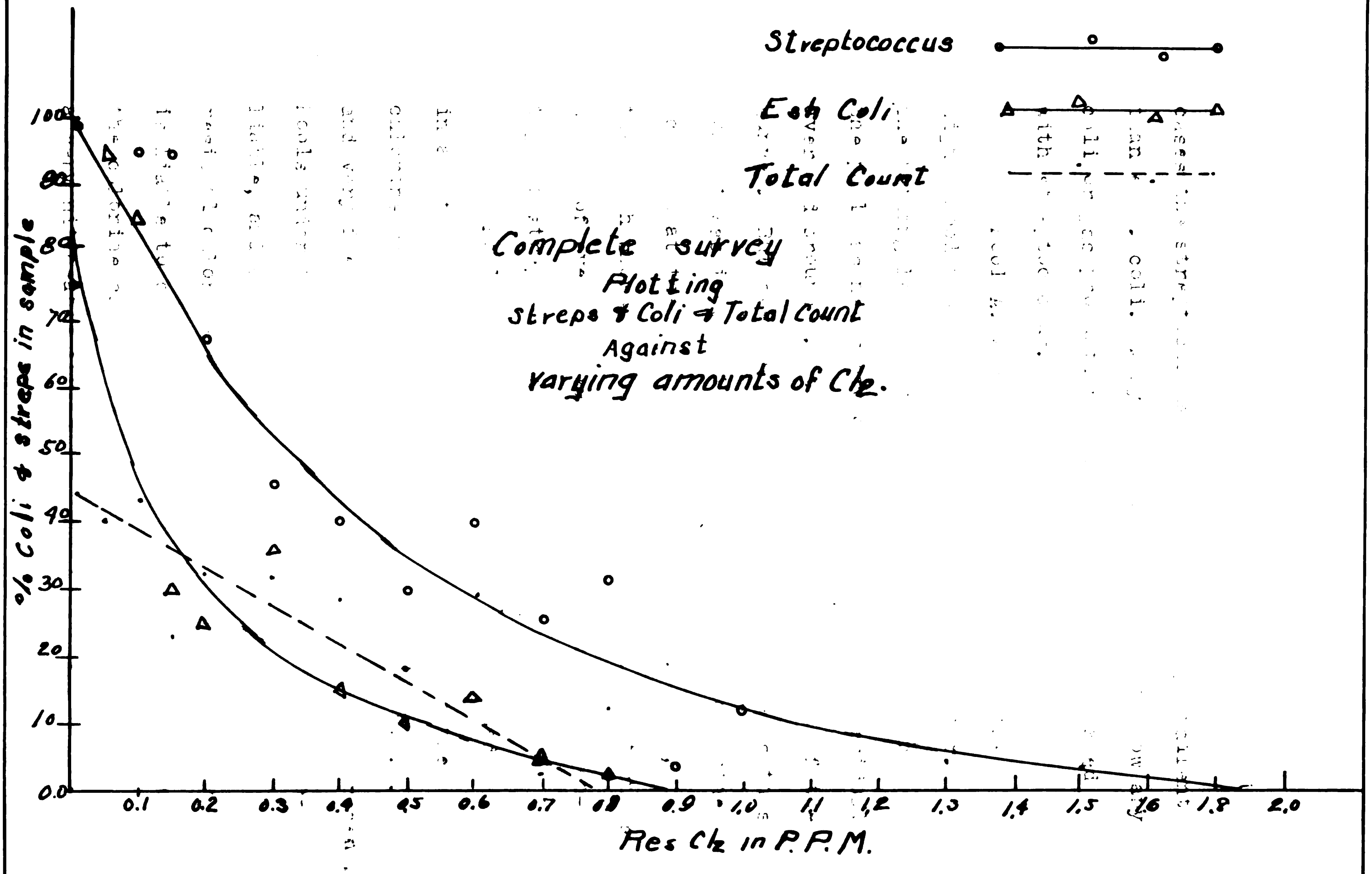
It is very essential to run a bacteriological test on a pool every day as well as to check the residual chlorine content. The necessary amount of chlorine to affect disinfection seems to vary with each pool.[1] Pools A and F. remained in good condition at about .5 P.P.M. of chlorine, while pools D. and E. had a high count, and were very badly polluted at .6 P.P.M. The size of pools and the bathing load probably had much to do with this. In general, when the bathing increases beyond a certain amount the pollution increases

This amount being different for each pool.

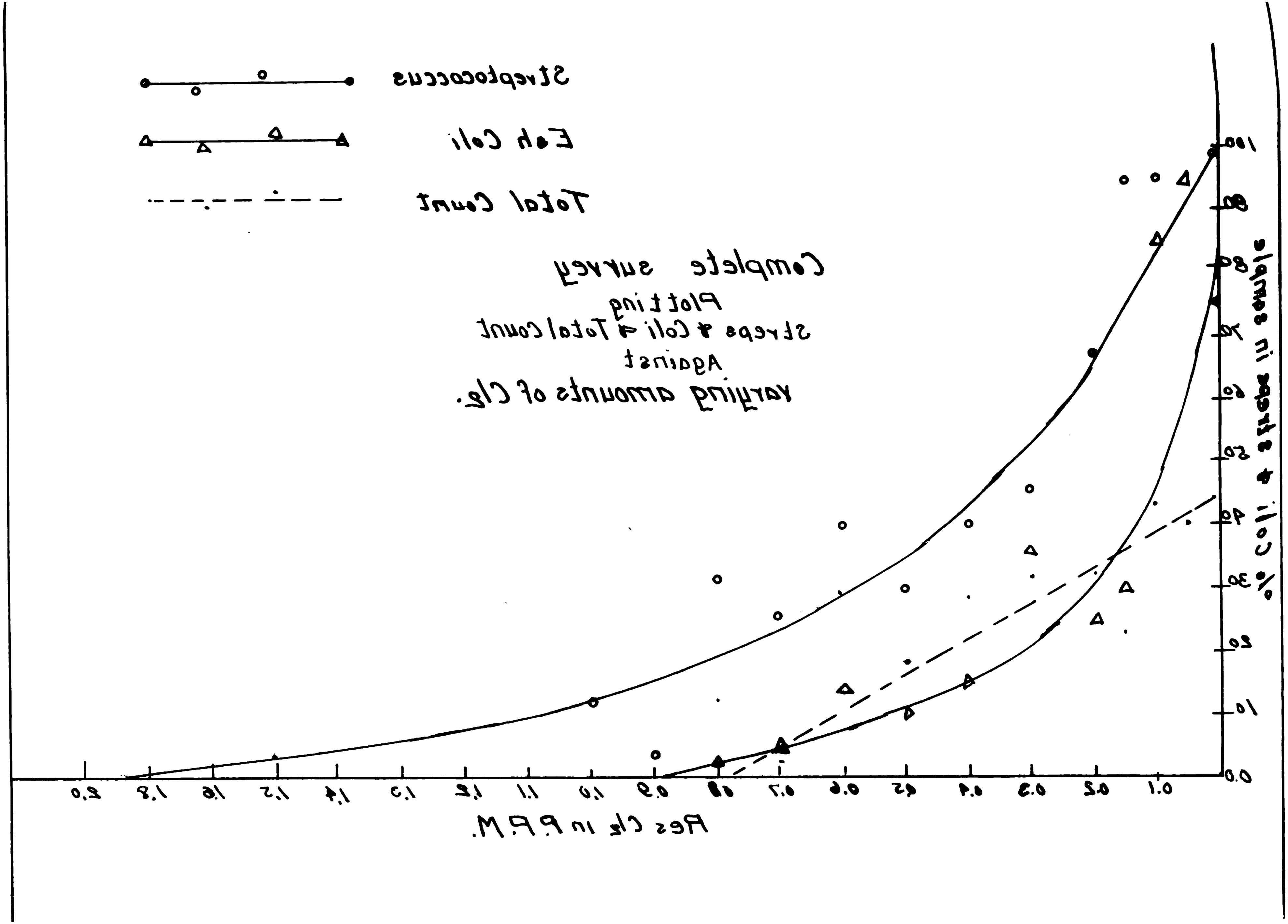
The question has been raised by many interested parties, "Is there a difference in sanitary condition between pools used by adults and those used for children?" The four weeks which this survey covers failed to show a relationship to exist under such conditions. They all seem to show heavy pollution under heavy bathing loads, and clean water under light loads, providing the residual chlorine remains around .5 P.P.M.

Much emphasis is placed on the total count in the A. P. H. A. Standard procedure, but as the data show on graph in this survey it is rather insignificant. For example, in many cases there were as high as nine tubes showing streptococcus and of a possible ten, yet the total count was practically nil. The reason for having a high percentage of streptococcus and no count may be due to the fact that streptococcus do not grow on plain agar plates. Judging from the data the total count is not very accurate.

The results which are shown on the graph of the complete survey strengthen greatly the idea advanced by Mallmann and Gelpi, that streptococcus should be used as an index of pollution of swimming pools in preference to the Escherichia Coli. Many of the cases during the survey showed streptococcus to be present when the chlorine was 0.6 P.P.M. andhigher. In all



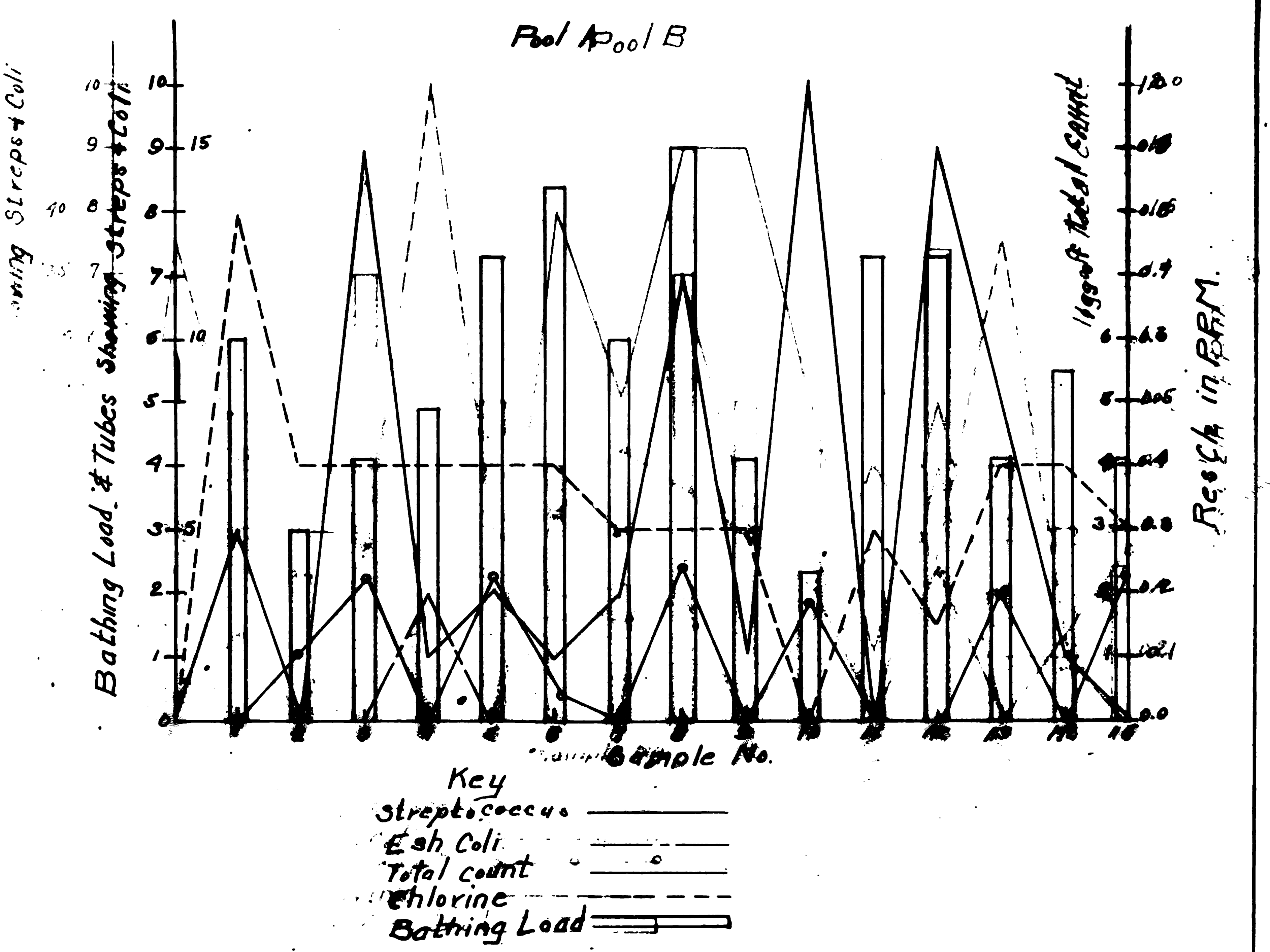
Streptococcus
Esh Coli
Total Count
Complete survey
Plotting
streps & Coli & Total Count
Against
varying amounts of Cl2.
% Coli & streps in sample
100
90
80
70
60
50
40
30
20
10
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.8
2.0
Res Cl2 in P.P.M.


Streptococcus
E. Coli
Total Count
Complete survey
Plotting
Streps & Coli & Total count
Against
varying amounts of Cl2.
% Coli & Streps in sample
Res Cl2 in P.P.M.

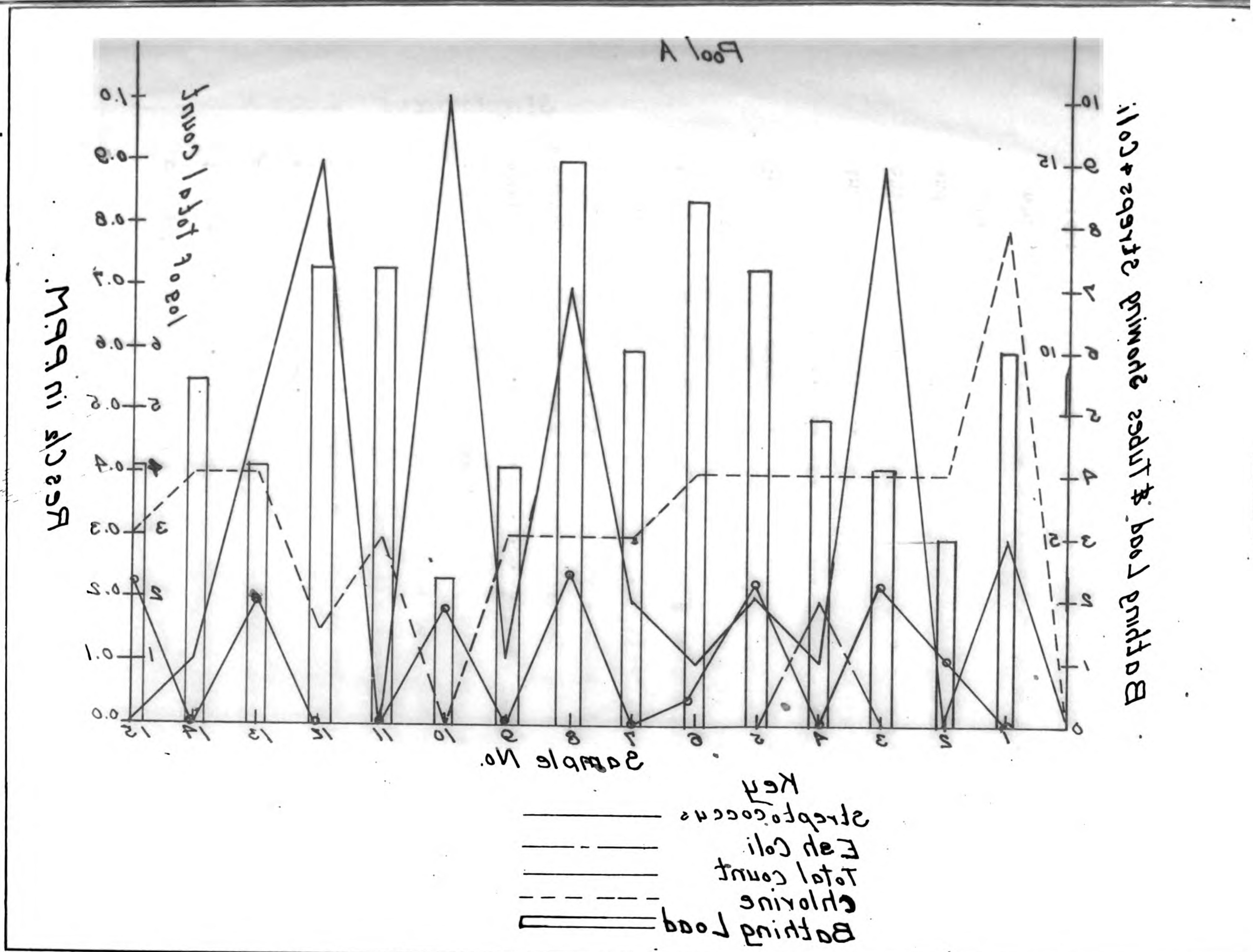
cases the streptococcus seemed to be more prevailent than esch. coli. Many cases in fact did not show any coli or gas production while the sample was loaded with streptococcus.

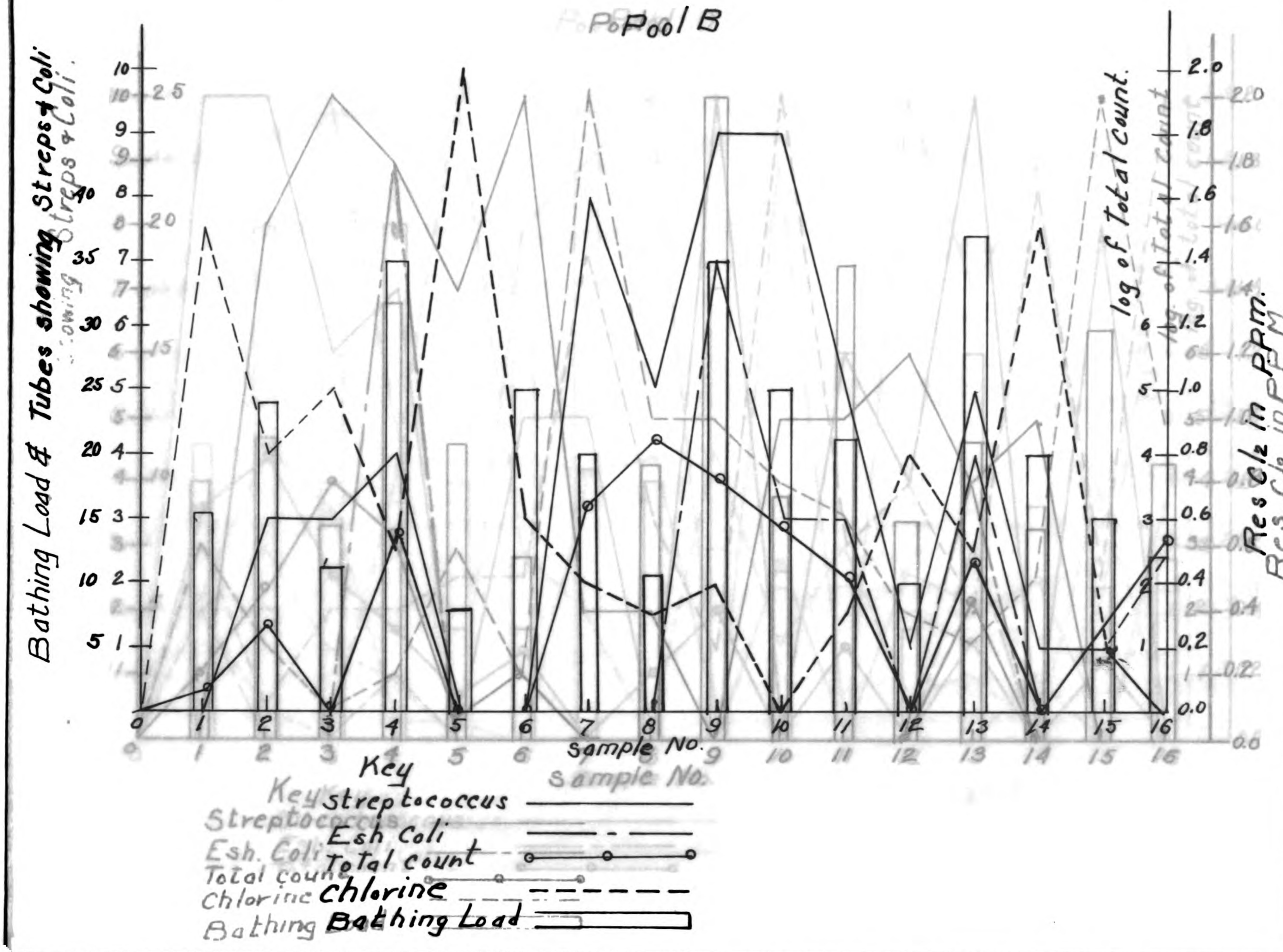
Pool A. was operated the best among the high school pools with the home made chlorinator. The bathing loads in this pool were kept down so the pool was never crowded, and the chlorine residual averaged around 0.3 to 0.4 P.P.M. through most of the survey. But even in a pool operated as close as this one it was impossible to keep the residual chlorine content at the right amount all the time. Also, the graph shows that there is a wild sample that shows up out of every few samples which has a high percentage of streptococcus.

Pools B., C., D., and E., were operated in about equal merits. In all of these pools the chlorine residual varied from 0.0 to 2. plus P.P.M. and very frequently theselimits of chlorine were present. Pools under those kind of supervision are very unreliable, and dangerous to the swimmer. When the residual chlorine content is 0.0 P.P.M. the swimmer is liable to contract disease from the water, and when the chlorine content is 2.P.P.M. or more it causes a very niticeable irritation to the swimmer.

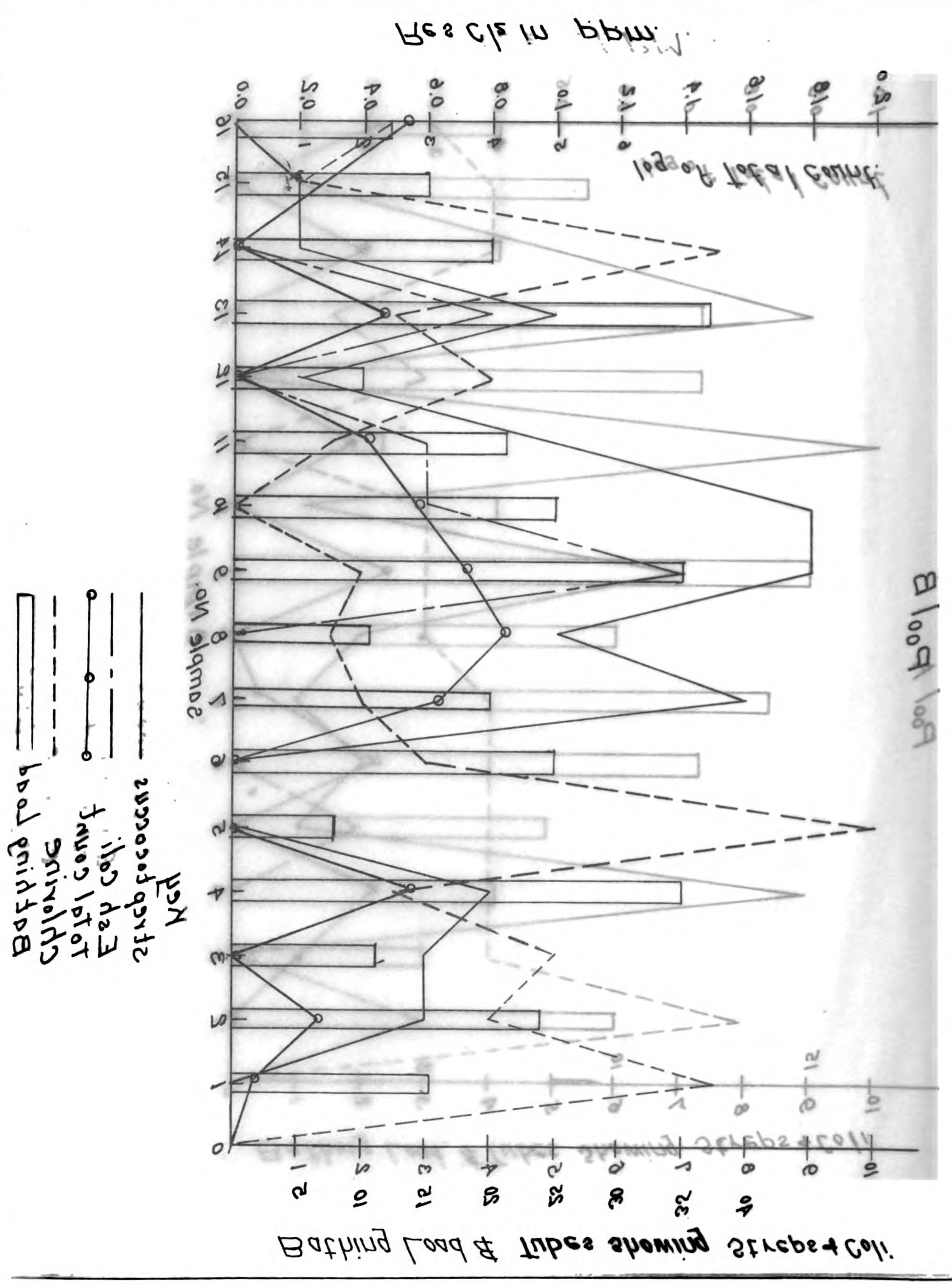


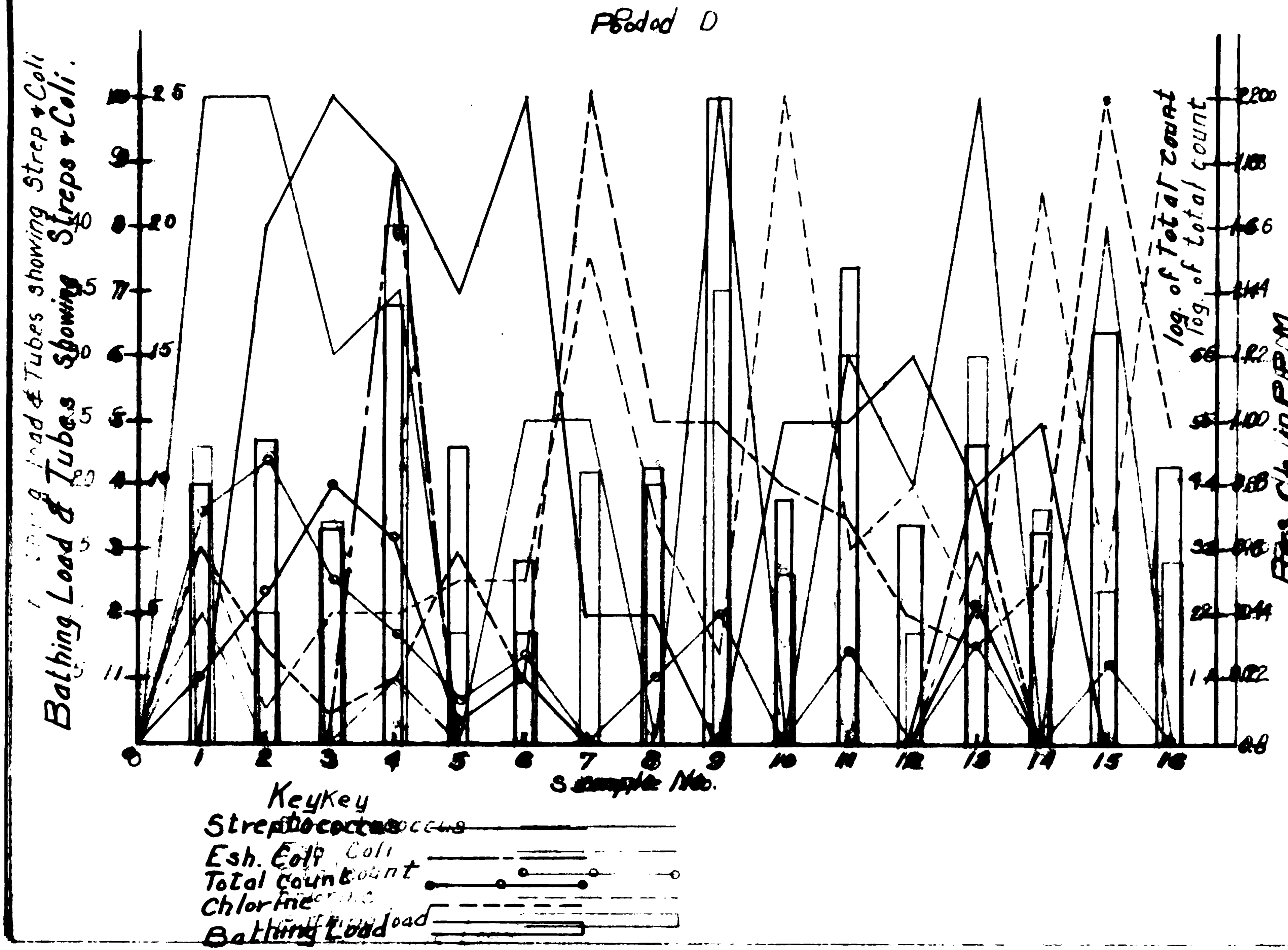
Pool A Pool B
Bathing Load. # Tubes Showing Streps + Coli
Log of Total Count
Res. Ch. in P.P.M.
Sample No.
Key
Streptococcus
Esh Coli
Total count
Chlorine
Bathing Load


Bathing Load & Tubes showing Streps + Coli.
Pool A
Results in P.P.M.
log of total count
Sample No.
Key
Streptococcus
Esh Coli
Total count
Chlorine
Bathing Load

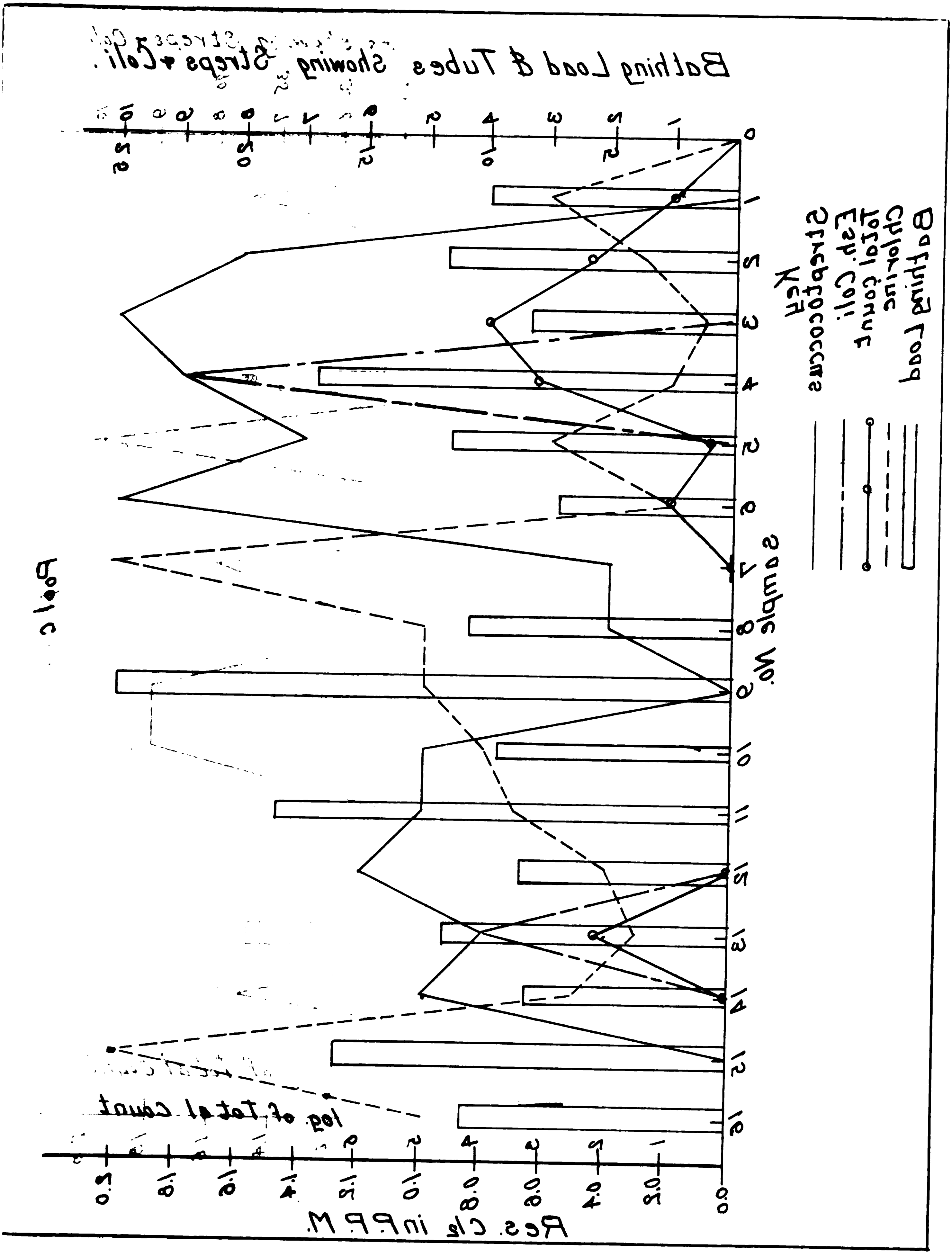


Pool B
Bathing Load & Tubes showing Streps + Coli
log of Total count.
Res Cl2 in PPM.
Sample No.
Key
streptococcus
Esh Coli
Total count
Chlorine
Bathing Load

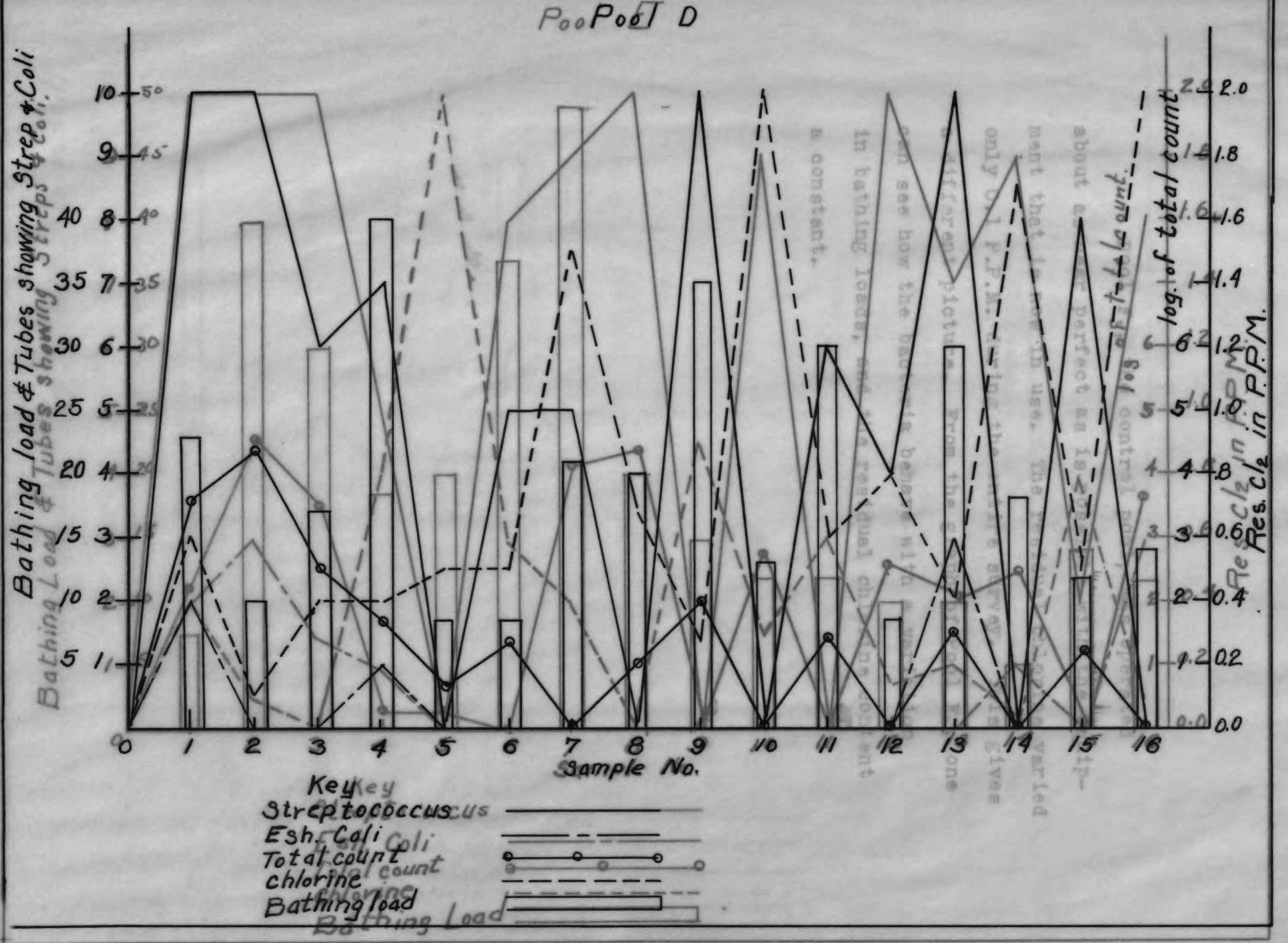

Bathing Load & Tubes showing Strep+Coli
Res Cl2 in ppm
log of Total Count
Pool B
Sample No.
Key
Bathing Load
Chlorine
Total Count
Esh Coli
Streptococcus

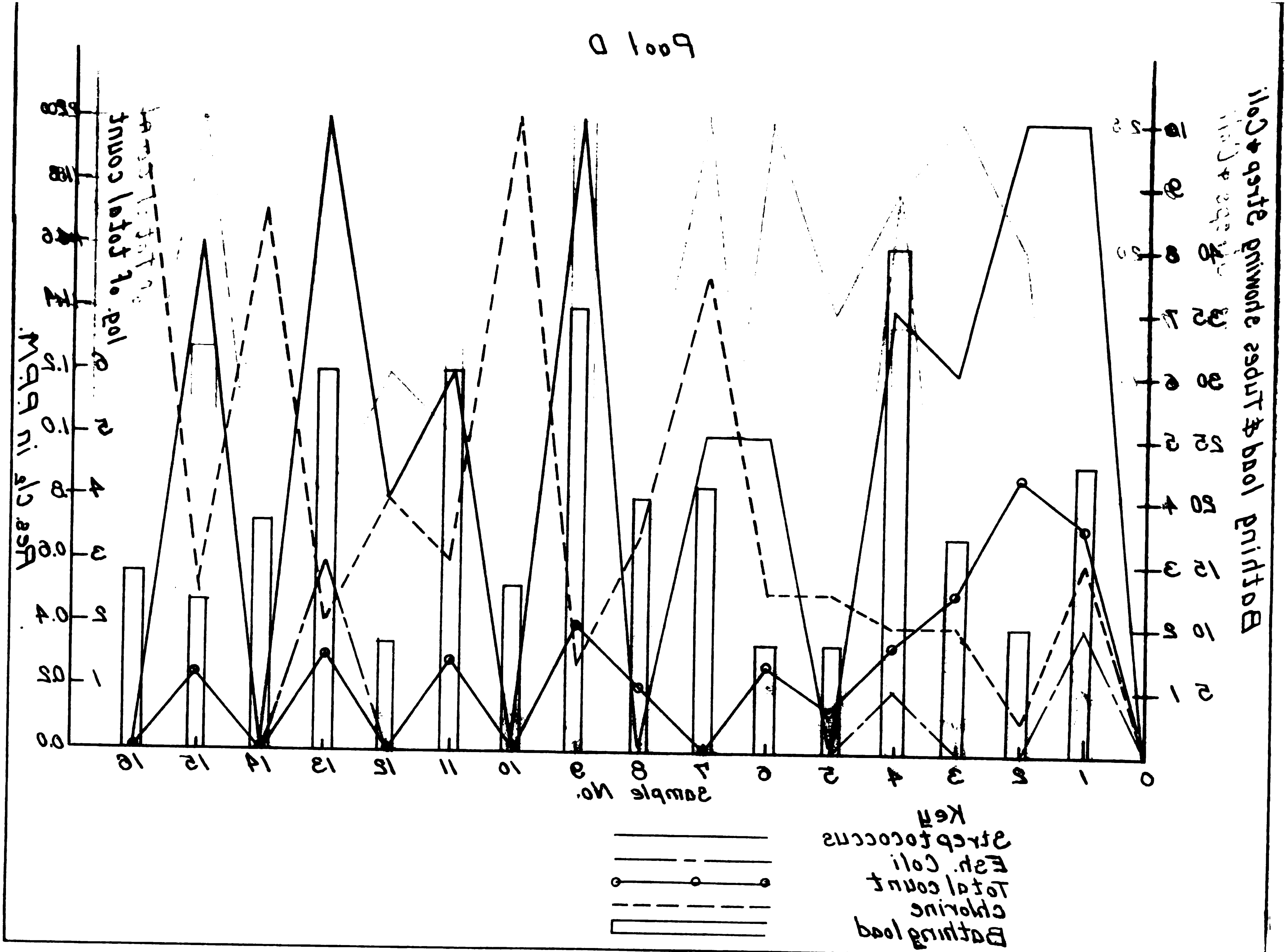


Period D
Bathing Load & Tubes Showing Streps + Coli.
log. of Total count
Res. Cl. in P.P.M.
Sample No.
Key
Streptococcus
Esh. Coli
Total count
Chlorine
Bathing Load



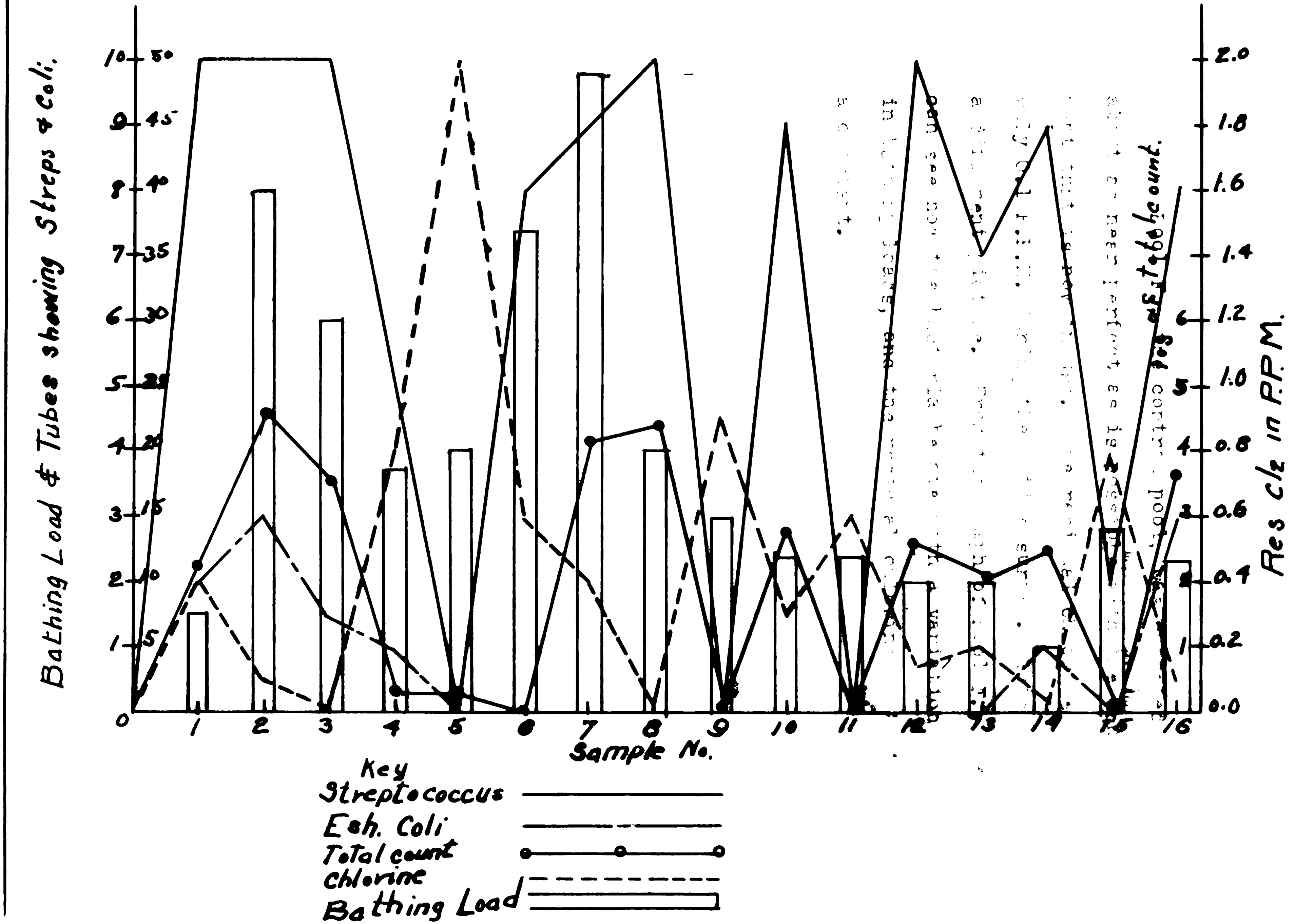
Bathing Load & Tubes Showing Streps + Coli.
Res. Cl2 in PPM.
log of total count
Sample No.
Pool C
Key
Bathing Load
Chlorine
Total Count
Esh. Coli
Streptococcus

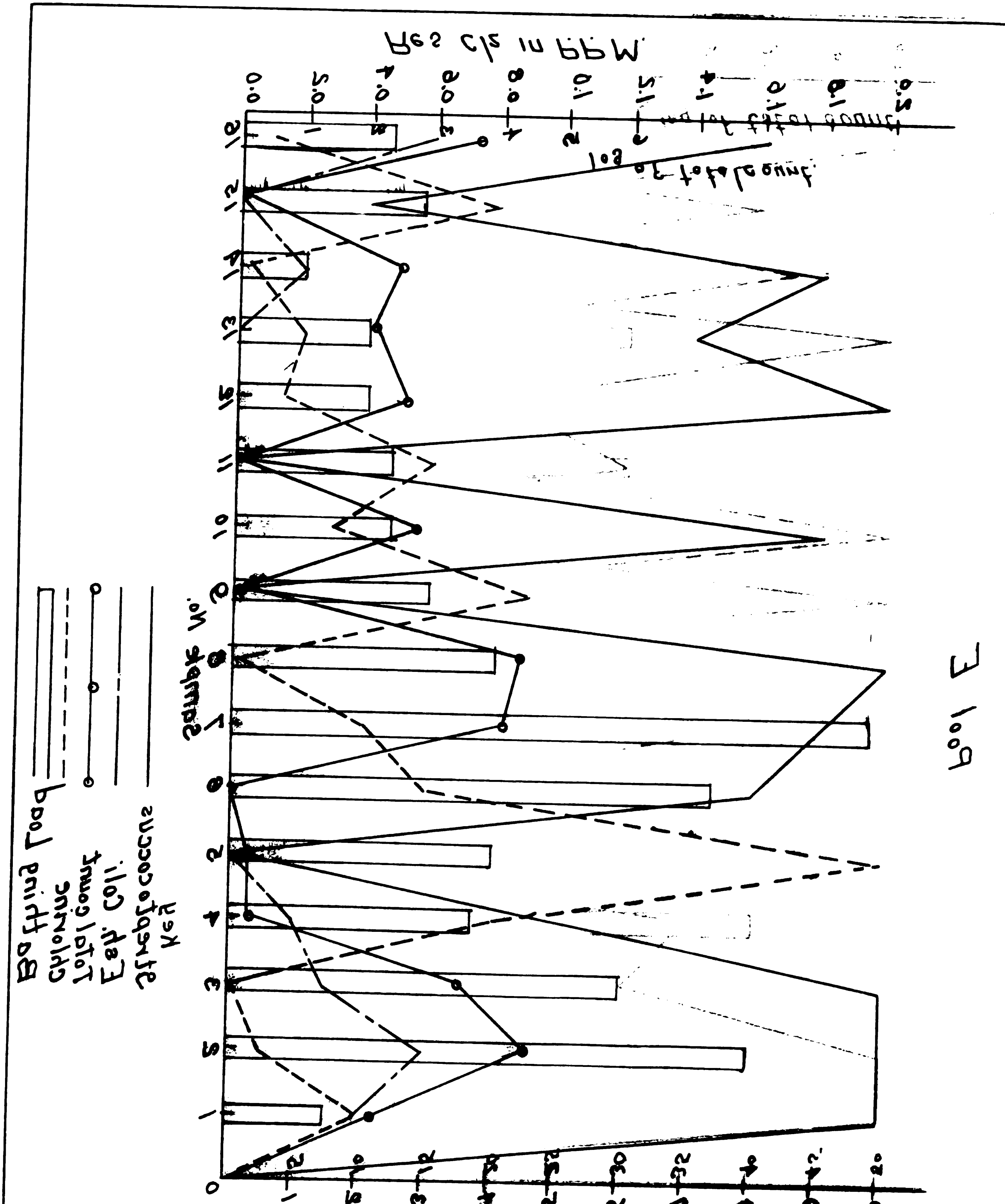

Pool D
Bathing load & Tubes showing Strep & Coli
log. of total count
Res. Cl_2 in P.P.M.
Sample No.
Key
Streptococcus
Esh. Coli
Total count
chlorine
Bathing load



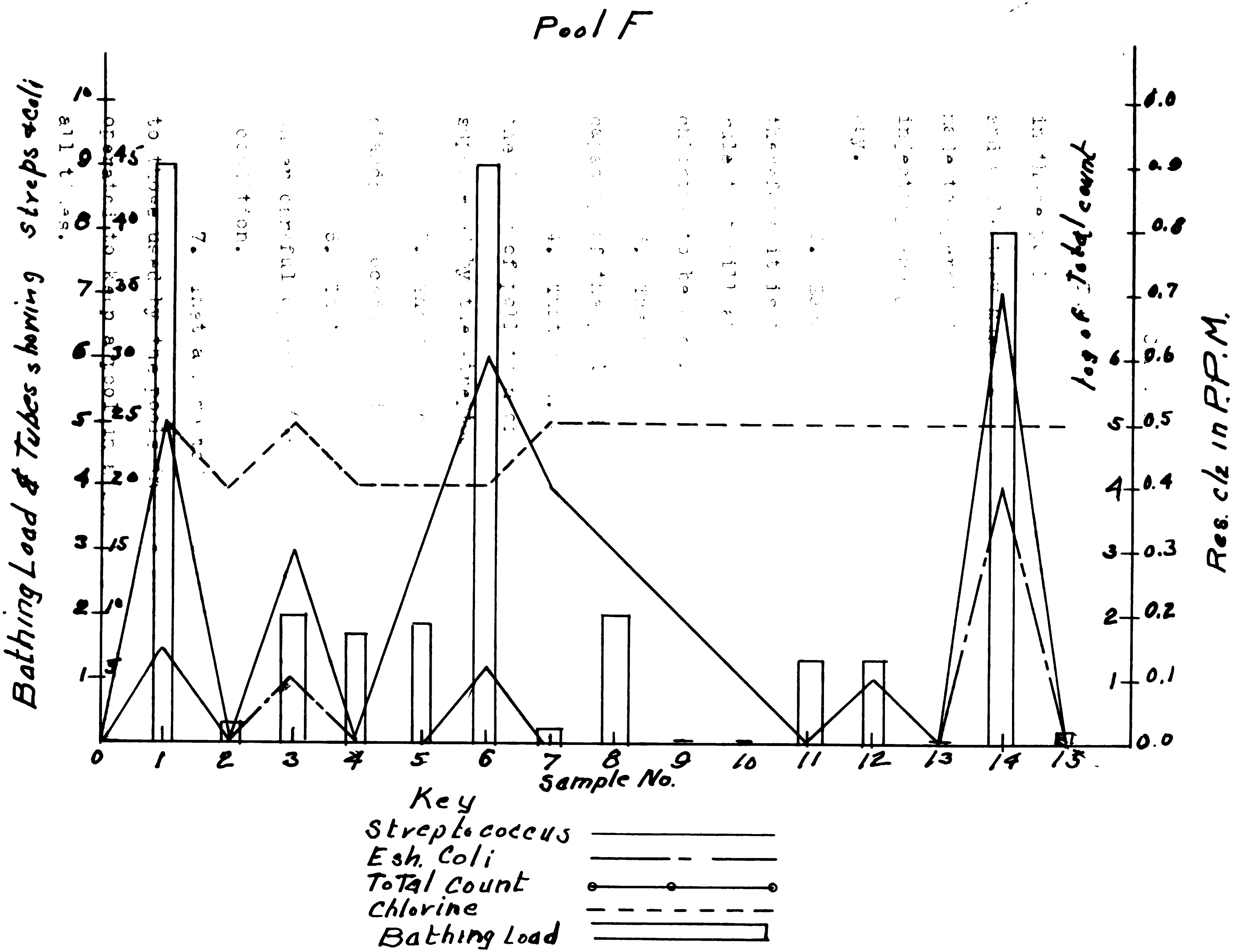
Pool D
Bathing load & Tubes showing Strep & Coli
Res. Cl2 in P.P.M.
log. of total count
Sample No.
Key
Streptococcus
Esh. Coli
Total count
chlorine
Bathing load

Pool E


Bathing Load & Tubes showing Streps & Coli.
Res Cl_2 in P.P.M.
Sample No.
Key
Streptococcus
Esh. Coli
Total count
chlorine
Bathing Load

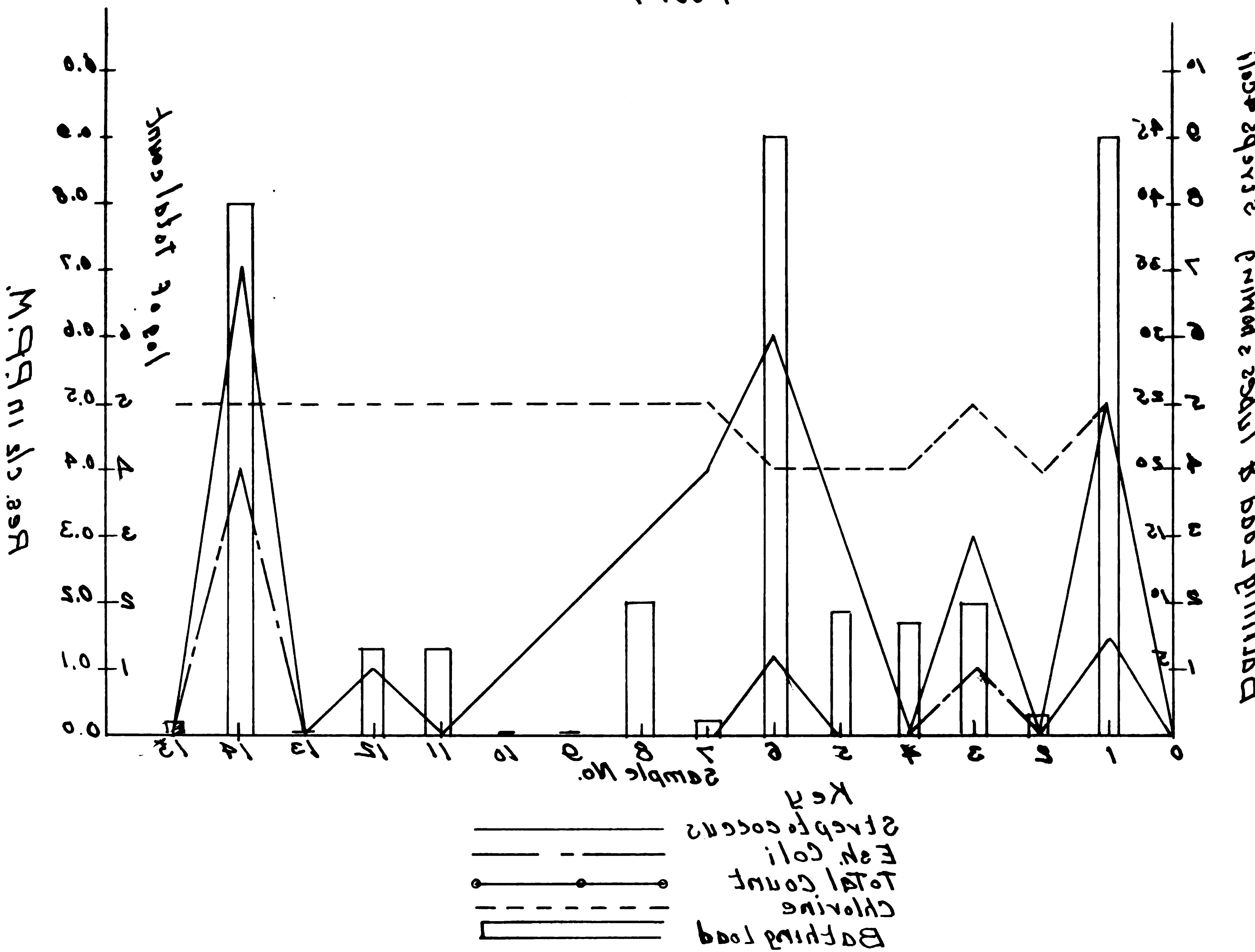

Bathing Load & Tubes showing Streps & Coli
Pool E
Res Cl2 in PPM
Sample No.
log of total count
Key
Bathing Load
Chlorine
Total Count
Esch. Coli
Streptococcus

Pool F., the control pool, was operated about as near perfect as is possible with the equipment that is now in use. The residual chlorine varied only 0.1 P.P.M. during the entire survey. This gives a different picture. From the graph of Pool F., one can see how the bacteria behave with a variation in bathing loads, and the residual chlorine content a constant.



Pool F
Bathing Load & Tubes showing streps & coli
log of Total count
Res. cl2 in P.P.M.
Sample No.
Key
Streptococcus
Esh. Coli
Total Count
Chlorine
Bathing Load

Pool F



Bathing Load & Tubes showing streps & coli
Res. cl2 in P.P.M.
log of total count
Sample No.
Key
Streptococcus
E. sh. Coli
Total Count
Chlorine
Bathing Load

CONCLUSIONS

1. The home made chlorinators that are used in these pools should be taken out as soon as possible, and while they must be in use an attempt should be made to operate them several times a day instead of injecting enough chlorine at one time to last for the day.

2. Each pool is a problem by itself and therefore it is impossible to set any hard and fast rule that will apply to all pools as to the amount of chlorine to be used.

3. The pollution seems to vary with the capacity of the pool and the bathing load.

4. That esch. coli and total count which is the index of pollution of swimming pools should be superceded by the streptococcus index.

5. The total count which is included as standard procedure is insignificant.

6. That a good chlorinator such as a Paradon under careful operation can keep a pool in first class condition.

7. That a home made chlorinator equivalent to those used by the pools in this survey cannot be operated to keep a pool in a sanitary condition at all times.

RECOMMENDATIONS

1. Replacement of home made chlorinators.

2. Careful supervision of chlorinator.

3. Instructions of operators as to the appreciation of pool sanitation, ortho-tolidine test, and explanation of bacty. tests.

4. Replacement of clean water by flooding into gutters daily.

5. Control bathing loads by cutting the size of the classes.

6. Maintainence of chlorine at approximately 0.5 P.P.M.

7. Continuous operation of circulators.

8. Supplanting esch. coli tests by streptococcus.

9. Use of dechlorinated sample bottles to collect pool samples.

10. General supervision of all pools by qualified athletic director.

ROOM USE ONLY