

107
044
THS

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

THESIS FOR THE DEGREE OF B. S.

Herbert J. Dunsmore

1933

Swimming pools - Sanitation

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

A Thesis Submitted to
The Faculty of
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND APPLIED SCIENCE

By

Herbert J. Dunsmore
Candidate for the Degree of
Bachelor of Science

June - 1933

ACKNOWLEDGEMENTS

The writer wishes to take this opportunity to thank Dr. W. L. Mallmann, and R. Faust for their help and advice in carrying out the work.

It is also a pleasure to thank the Department of Bacteriology for the use of equipment and stock, that was necessary to carry on this experiment.

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 of the first disinfectants used was ozone, followed shortly by 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 dilution through the introduction 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 such a condition with chlorine when introduced either as liquid chlorine or hypochloride. 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 r.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. The college 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 tube containing approximately 10 c. c. of double strength lactose broth. The tubes were incubated at 37° 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° 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 methylene 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 Paradox 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 $2\frac{1}{2}$ " 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 $8\frac{1}{2}$ ' deep at the deep end and $3\frac{1}{2}$ ' 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 $2\frac{1}{2}$ " discharge, a rate of 225 gallons per minute, and a turn over of six hours. The pump is in operation about $20\frac{1}{2}$ hours daily. It has two $4\frac{1}{2}$ " 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 $3\frac{1}{2}$ ' 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 $1\frac{1}{2}$ " discharge, a rate of 150 gallons per minute, and a turn over of $5\frac{1}{2}$ 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 $7\frac{1}{2}$ ' deep at the deep end and $2\frac{1}{2}$ ' at the shallow end. The pool is 20' wide and $48\frac{1}{2}$ ' 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 $3\frac{1}{2}$ ' 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	-----	spsps	--	--
	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	Resid- uary cl2 in P.P.M.	Esh. Coli	Strep- tococcus	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	Strep-tococcus	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--	pspps	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	0.8	-----	-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

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490	1491	149
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	-----

DATA ARRANGED WITH DECREASING AMOUNTS OF CHLORINE

Source	No.	Bath Load	Resid-uary Cl ₂ in P.P.M.	Esh. Coli	Strep- tococcus	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	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
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

		Date		Time		Location	

Source	No.	Bath Load	Resid- uary Cl ₂ in P.P.M.	Esh. Coli	Strep- tococcus	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 Cl ₂ in P.P.M.	Esh. Coli	Strep-tococcus	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	-----	ssps	--	--
	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.	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.	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.	188	8F	0.4	-----	ppp--	0	0
	189	8F	0.4	-----	ppp--	0	0
D.	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.	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.	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

[illegible]

Source	No.	Bath Load	Resid- uary Cl ₂ in P.P.M.	Esh. Coli	Strep- tococcus	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	0.2	-----	-----	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	Residuary 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	apppp	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

REF 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

[illegible][illegible]

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 system. 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 device. 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 2.1 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: $2\text{Cl} + \text{H}_2\text{O}$ equals $\text{HOCL} + \text{HCL}$. Then the hypochlorous acid unites with the basic salts of the water, for example, $\text{HOCL} + \text{Na}_2\text{CO}_3$ equals $\text{NaOCL} + \text{H}_2\text{O}$. The sodium hypo-chlorite being very unstable combines with the water as $\text{NaOCL} + \text{H}_2\text{O}$ equals $\text{HOCL} + \text{NaOH}$. The hypochlorous acid (HOCL) of this reaction being unstable breaks down as in equation HOCL equals $\text{HCL} + \text{O}$ 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. 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.

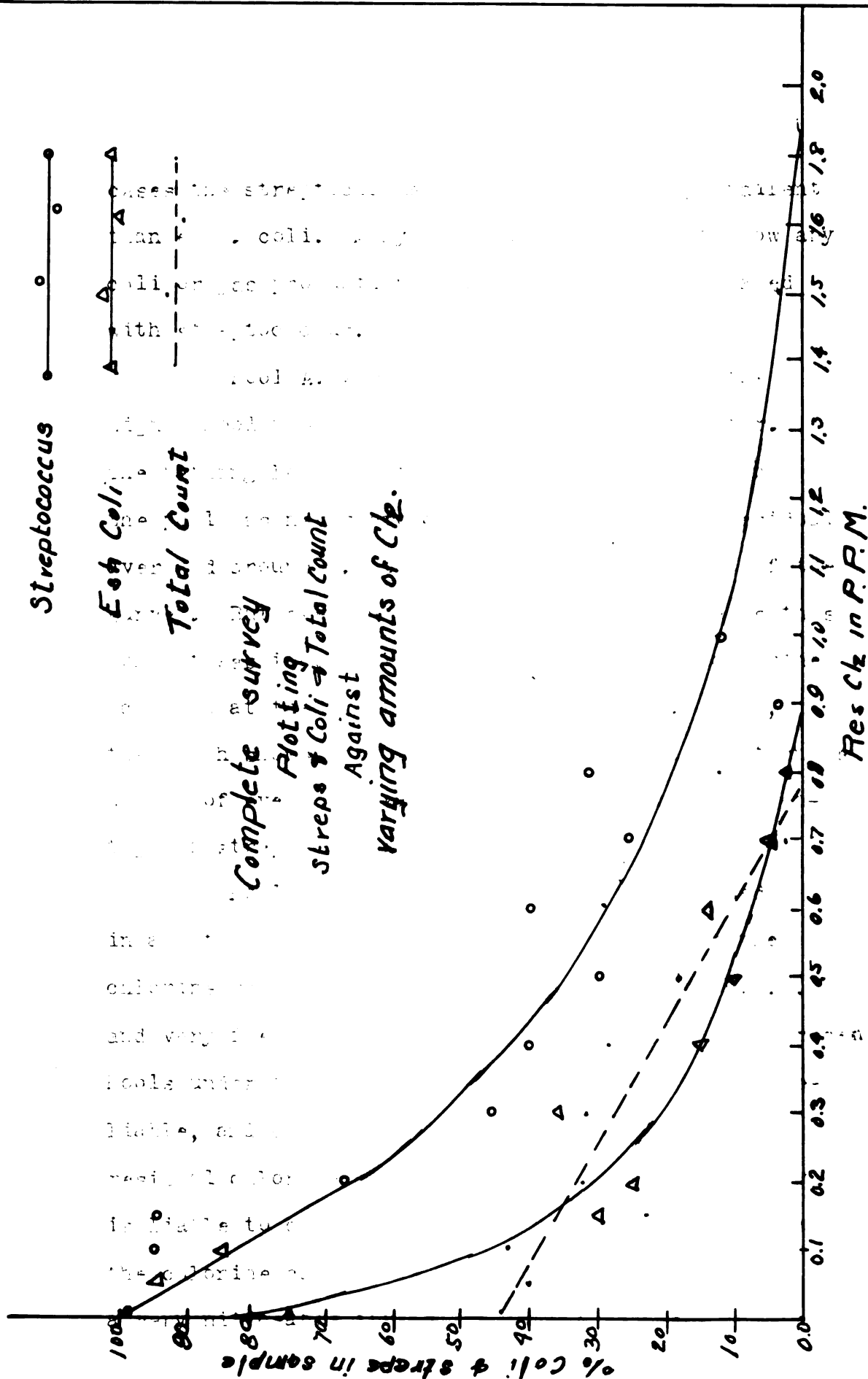
Much emphasis is placed on the total count in the A. P. H. A. Standard procedure, but as the data show on graph in this survey it is rather insignificant. For example, in many cases there were as high as nine tubes showing streptococcus and of a possible ten, yet the total count was practically nil. 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. and higher. In all

Streptococcus

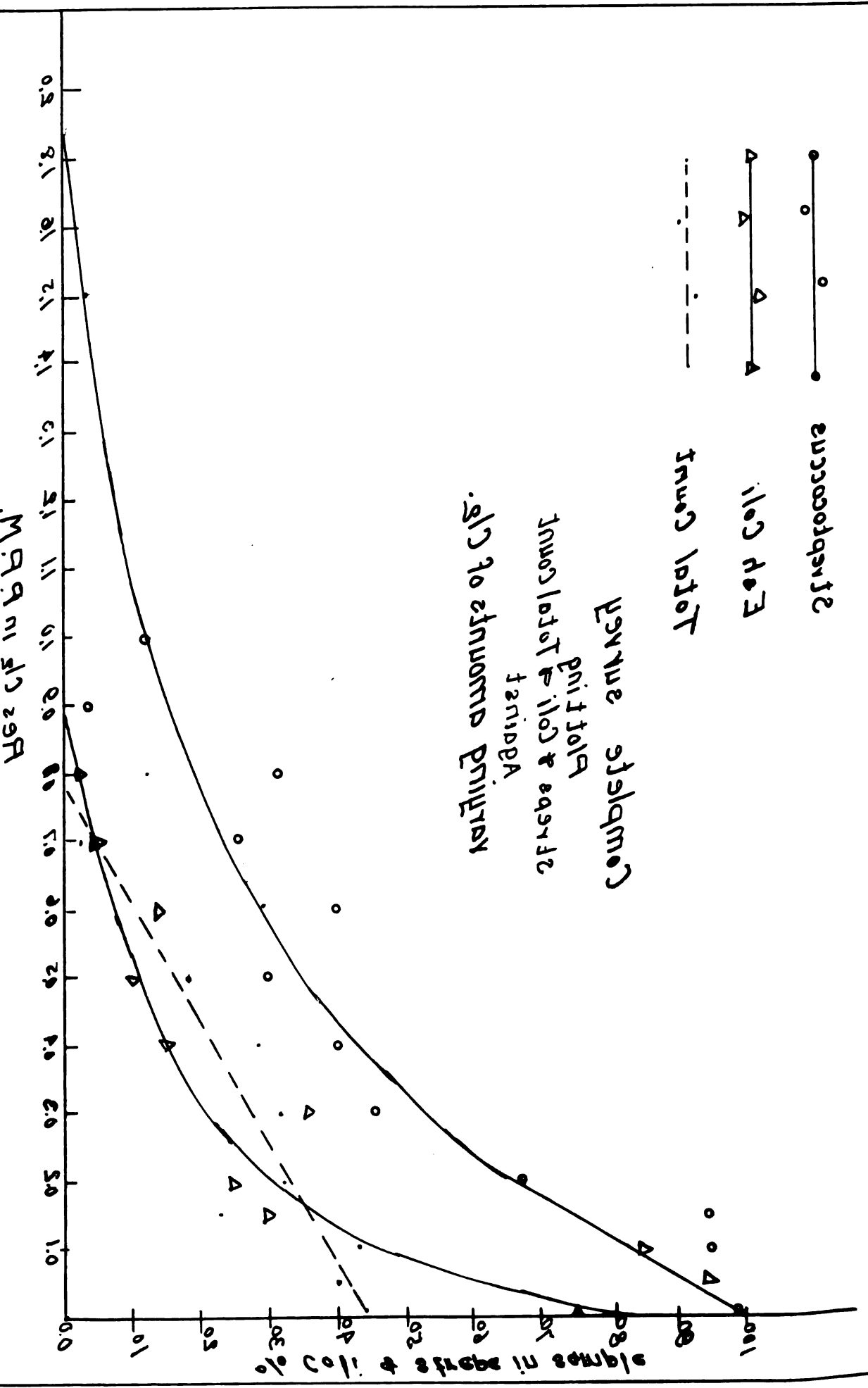
E. coli
Total Count

Complete survey
Plotting
Streps & Coli → Total Count
Against
Varying amounts of Cl₂.



i
l
.
l
l
.
l
l

taniga
to 2nd year

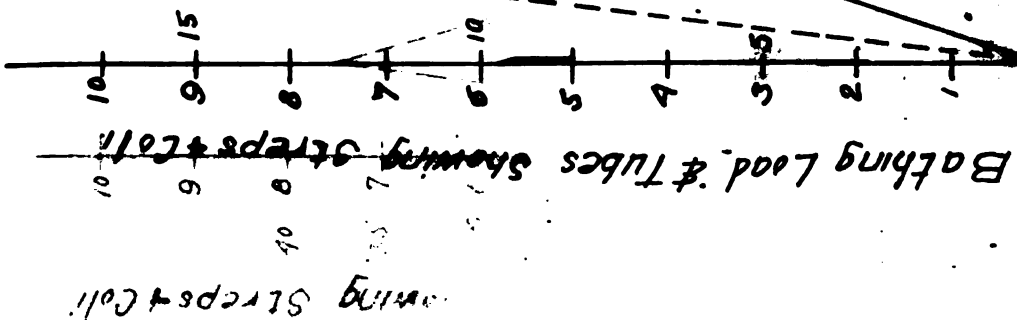


cases the streptococcus seemed to be more prevalent than esch. coli. Many cases in fact did not show any coli or gas production while the sample was loaded with streptococcus.

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.

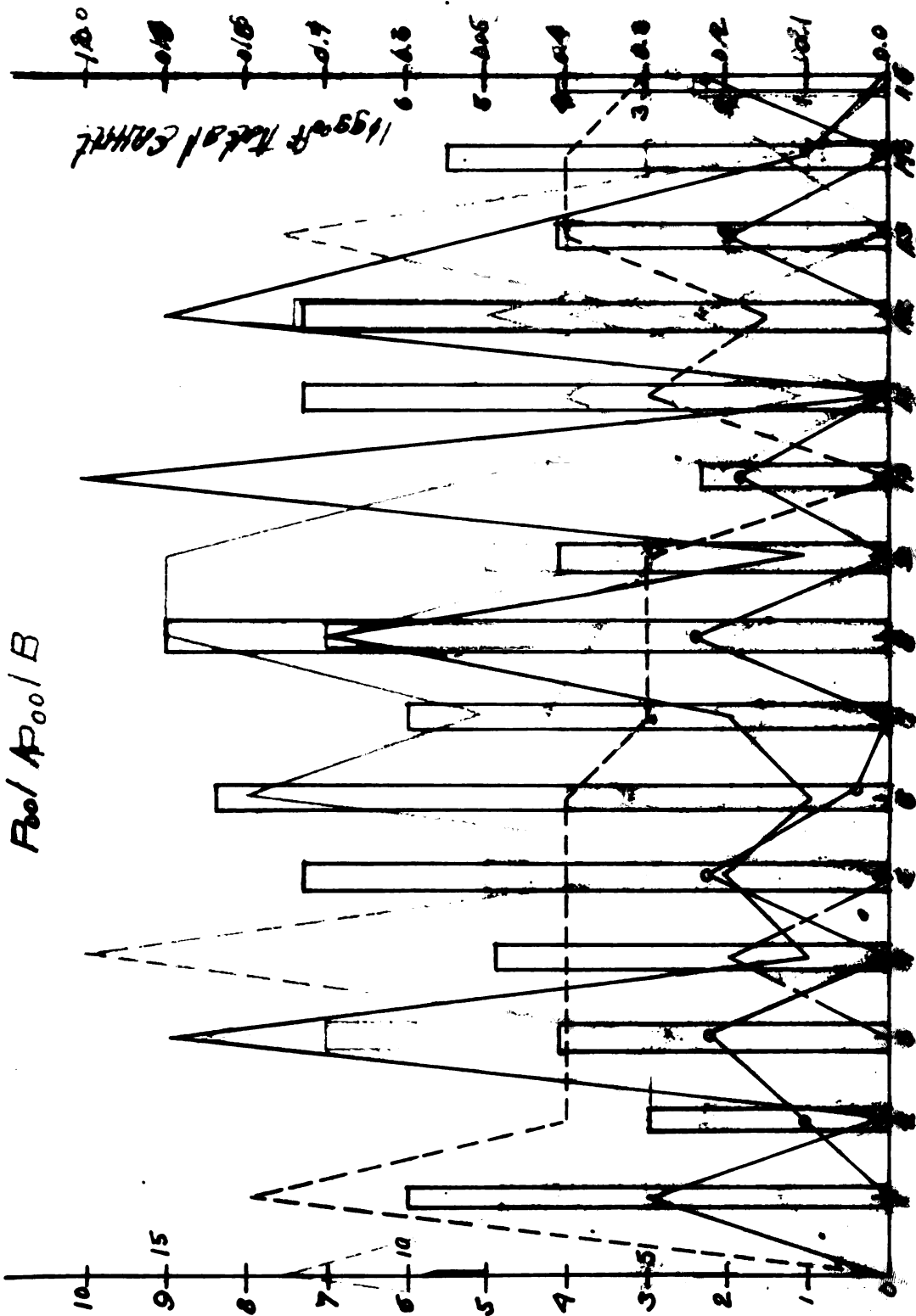
Pools B., C., D., and E., were operated in about equal merits. In all of these pools the chlorine residual varied from 0.0 to 2. plus P.P.M. and very frequently these limits of chlorine were present. Pools under those kind of supervision are very unreliable, and dangerous to the swimmer. When the residual 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 noticeable irritation to the swimmer.

Pool A₀₀₁B

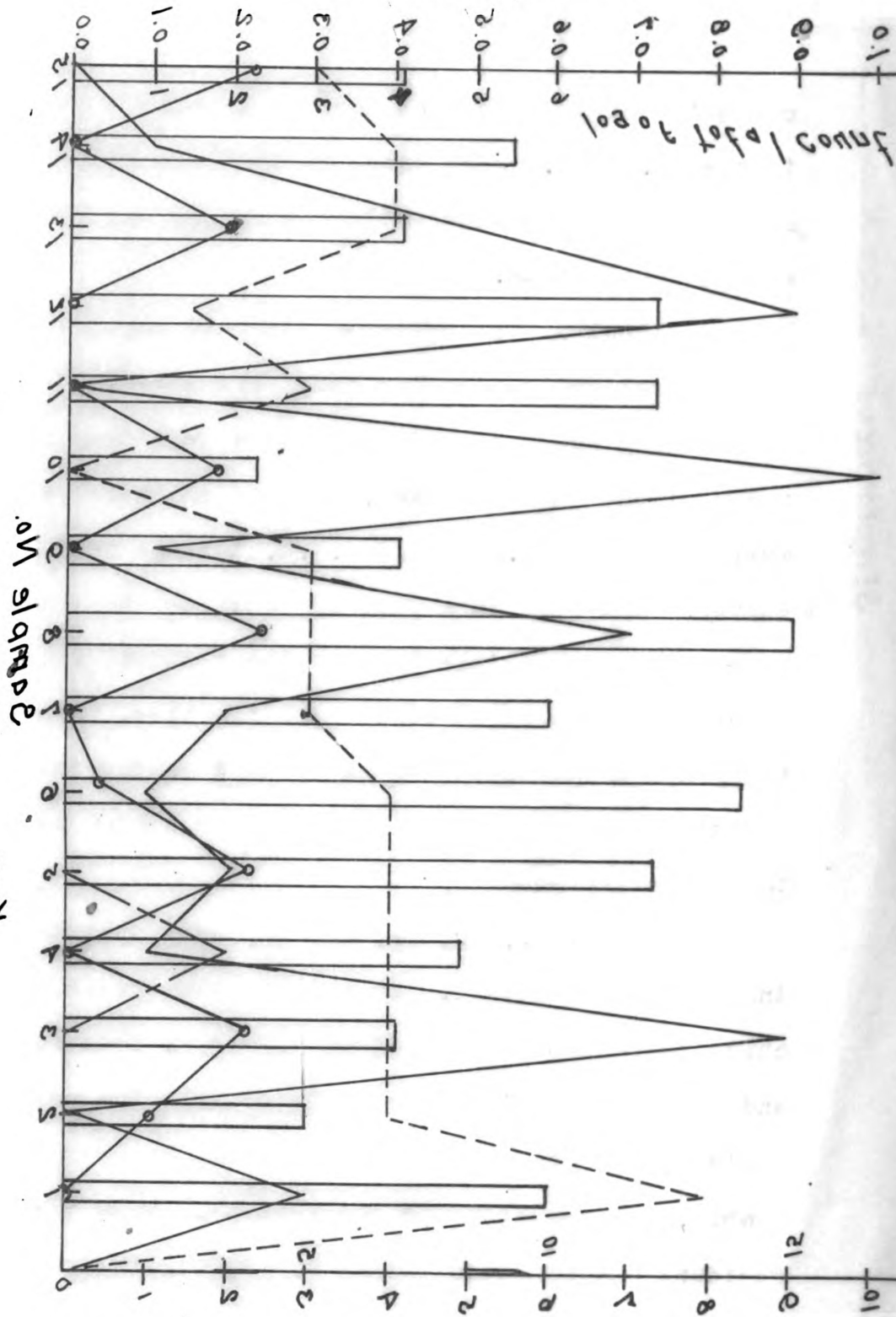


Key

- Streptococcus ———
- Coli - - - - -
- Total count
- Chlorine
- Bathing Load



RES CS IN PPW

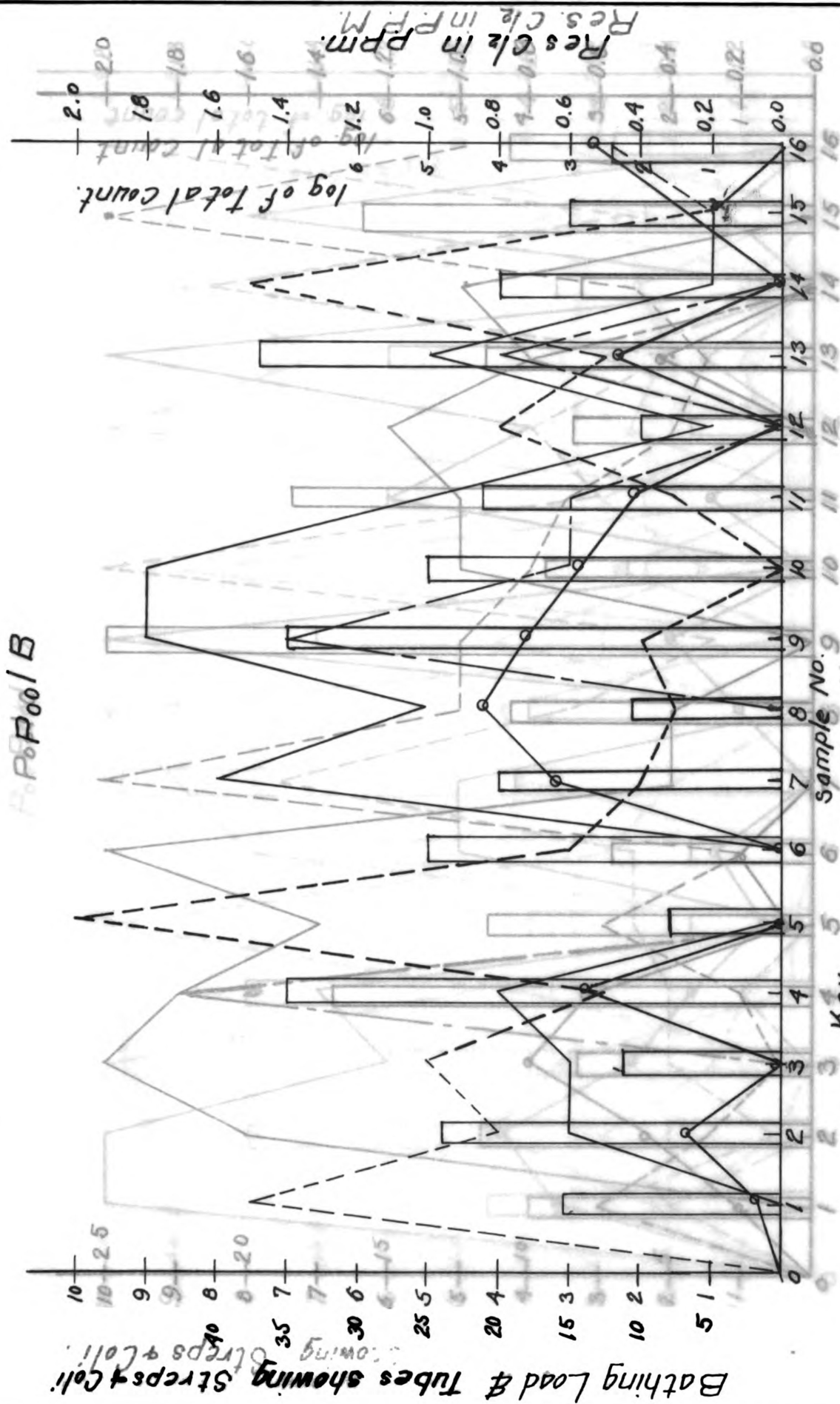


A / log A

Bathing Load & Types showing stages + coll.

Bathing Load
 Chlorine
 Total count
 Ear Coll.
 Stages No.
 log of total count

P6P00/B



Key

Key Streptococcus

E. coli

Esh. Coli Total count

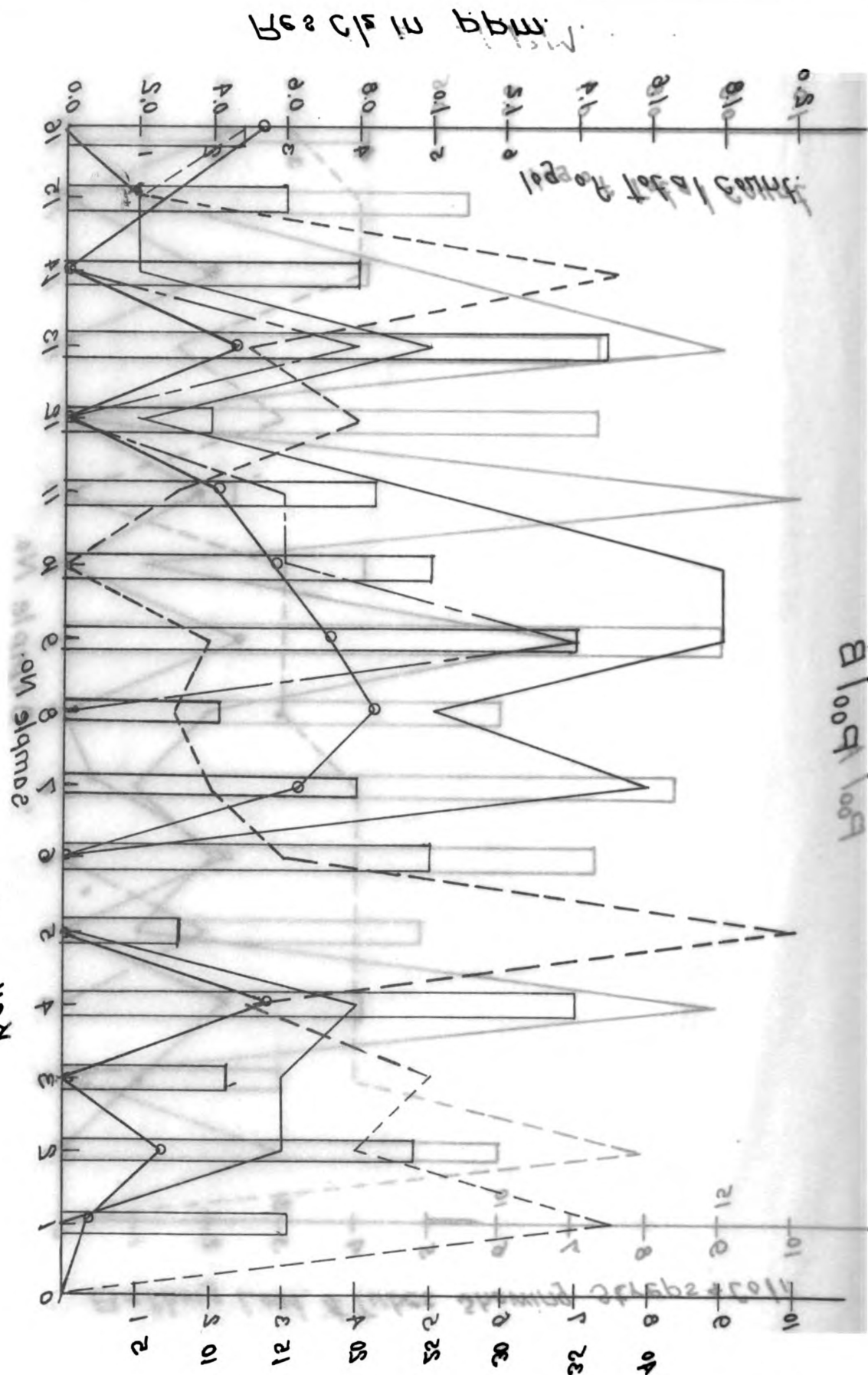
Total count: 177

Chlorine

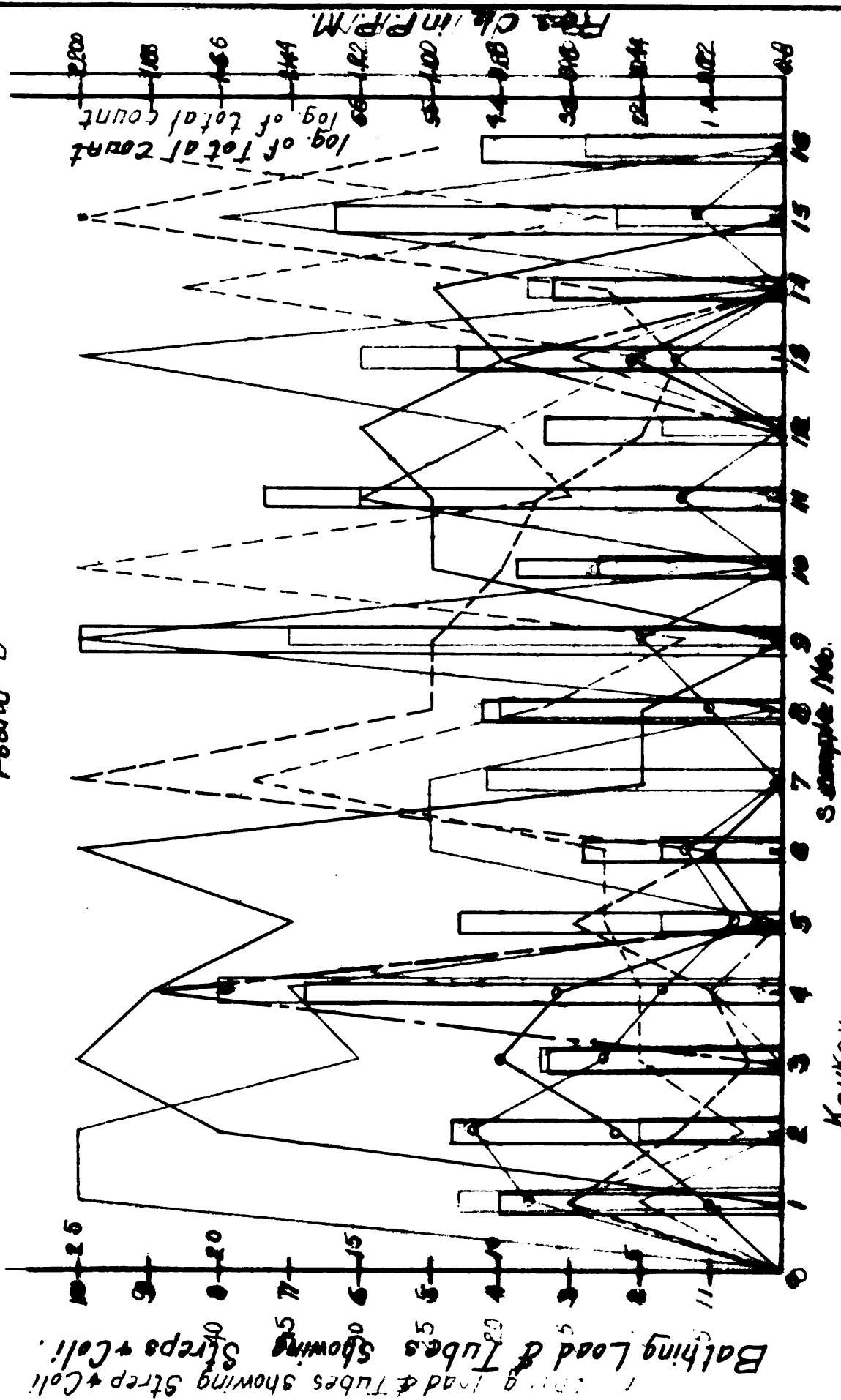
Bathing Load

1109 + 29312 private adult & baby print to B

2024
 2023
 2022
 2021
 2020
 2019
 2018
 2017
 2016
 2015
 2014
 2013
 2012
 2011
 2010
 2009
 2008
 2007
 2006
 2005
 2004
 2003
 2002
 2001
 2000
 1999
 1998
 1997
 1996
 1995
 1994
 1993
 1992
 1991
 1990
 1989
 1988
 1987
 1986
 1985
 1984
 1983
 1982
 1981
 1980
 1979
 1978
 1977
 1976
 1975
 1974
 1973
 1972
 1971
 1970
 1969
 1968
 1967
 1966
 1965
 1964
 1963
 1962
 1961
 1960
 1959
 1958
 1957
 1956
 1955
 1954
 1953
 1952
 1951
 1950
 1949
 1948
 1947
 1946
 1945
 1944
 1943
 1942
 1941
 1940
 1939
 1938
 1937
 1936
 1935
 1934
 1933
 1932
 1931
 1930
 1929
 1928
 1927
 1926
 1925
 1924
 1923
 1922
 1921
 1920
 1919
 1918
 1917
 1916
 1915
 1914
 1913
 1912
 1911
 1910
 1909
 1908
 1907
 1906
 1905
 1904
 1903
 1902
 1901
 1900
 1899
 1898
 1897
 1896
 1895
 1894
 1893
 1892
 1891
 1890
 1889
 1888
 1887
 1886
 1885
 1884
 1883
 1882
 1881
 1880
 1879
 1878
 1877
 1876
 1875
 1874
 1873
 1872
 1871
 1870
 1869
 1868
 1867
 1866
 1865
 1864
 1863
 1862
 1861
 1860
 1859
 1858
 1857
 1856
 1855
 1854
 1853
 1852
 1851
 1850
 1849
 1848
 1847
 1846
 1845
 1844
 1843
 1842
 1841
 1840
 1839
 1838
 1837
 1836
 1835
 1834
 1833
 1832
 1831
 1830
 1829
 1828
 1827
 1826
 1825
 1824
 1823
 1822
 1821
 1820
 1819
 1818
 1817
 1816
 1815
 1814
 1813
 1812
 1811
 1810
 1809
 1808
 1807
 1806
 1805
 1804
 1803
 1802
 1801
 1800
 1799
 1798
 1797
 1796
 1795
 1794
 1793
 1792
 1791
 1790
 1789
 1788
 1787
 1786
 1785
 1784
 1783
 1782
 1781
 1780
 1779
 1778
 1777
 1776
 1775
 1774
 1773
 1772
 1771
 1770
 1769
 1768
 1767
 1766
 1765
 1764
 1763
 1762
 1761
 1760
 1759
 1758
 1757
 1756
 1755
 1754
 1753
 1752
 1751
 1750
 1749
 1748
 1747
 1746
 1745
 1744
 1743
 1742
 1741
 1740
 1739
 1738
 1737
 1736
 1735
 1734
 1733
 1732
 1731
 1730
 1729
 1728
 1727
 1726
 1725
 1724
 1723
 1722
 1721
 1720
 1719
 1718
 1717
 1716
 1715
 1714
 1713
 1712
 1711
 1710
 1709
 1708
 1707
 1706
 1705
 1704
 1703
 1702
 1701
 1700
 1699
 1698
 1697
 1696
 1695
 1694
 1693
 1692
 1691
 1690
 1689
 1688
 1687
 1686
 1685
 1684
 1683
 1682
 1681
 1680
 1679
 1678
 1677
 1676
 1675
 1674
 1673
 1672
 1671
 1670
 1669
 1668
 1667
 1666
 1665
 1664
 1663
 1662
 1661
 1660
 1659
 1658
 1657
 1656
 1655
 1654
 1653
 1652
 1651
 1650
 1649
 1648
 1647
 1646
 1645
 1644
 1643
 1642
 1641
 1640
 1639
 1638
 1637
 1636
 1635
 1634
 1633
 1632
 1631
 1630
 1629
 1628
 1627
 1626
 1625
 1624
 1623
 1622
 1621
 1620
 1619
 1618
 1617
 1616
 1615
 1614
 1613
 1612
 1611
 1610
 1609
 1608
 1607
 1606
 1605
 1604
 1603
 1602
 1601
 1600
 1599
 1598
 1597
 1596
 1595
 1594
 1593
 1592
 1591
 1590
 1589
 1588
 1587
 1586
 1585
 1584
 1583
 1582
 1581
 1580
 1579
 1578
 1577
 1576
 1575
 1574
 1573
 1572
 1571
 1570



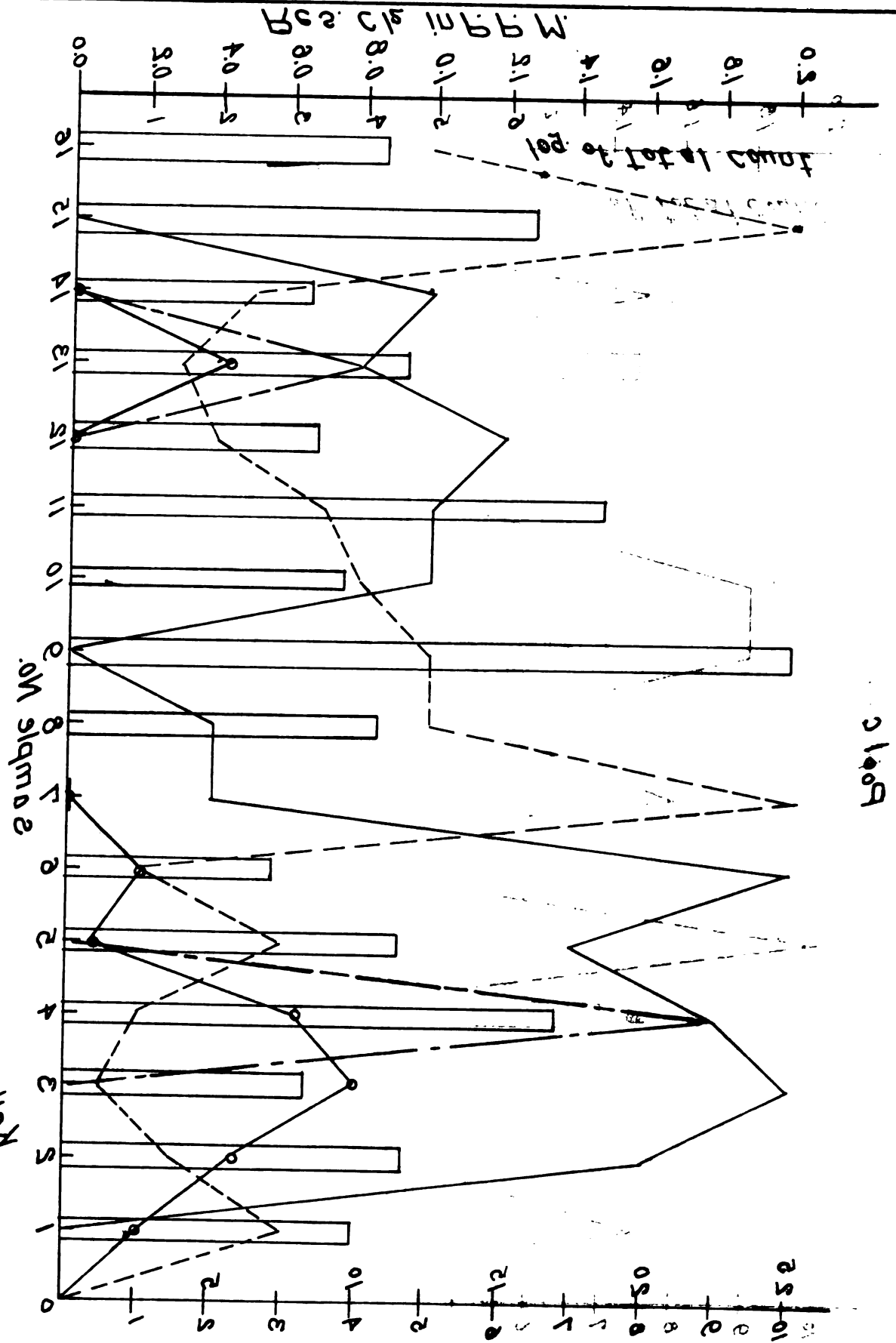
Food D



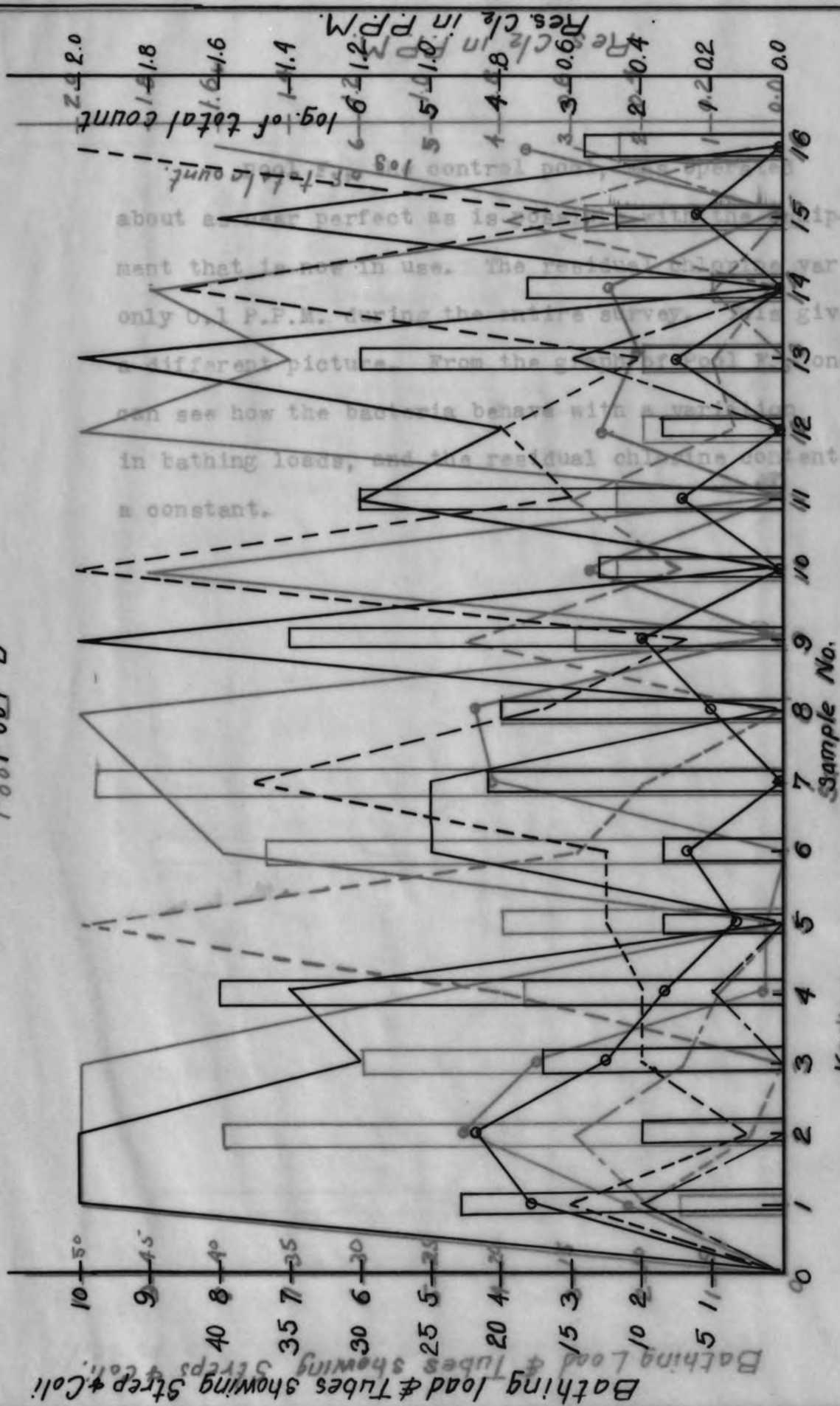
Streptococcus
E. coli
Total count
Chlorine
Bathing load

Bathing Load & Types of Animals Showing Stripes + Coli.

Bathing Load
 Chlorine
 Total Coli
 E. coli
 Streptococci
 MSA



Poo Poo D



Strepptococcus

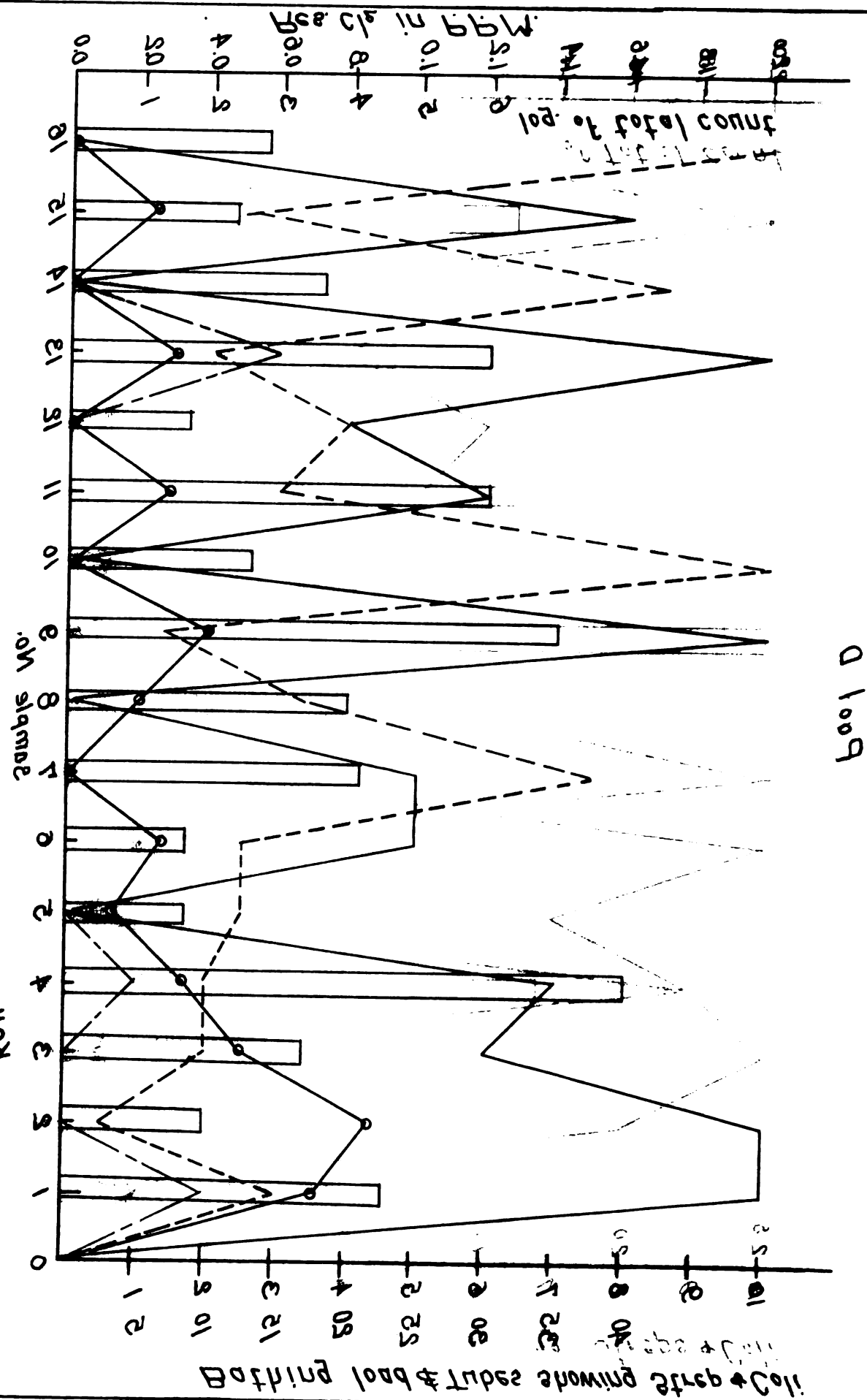
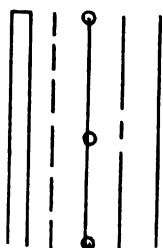
Esh. Coli

Total count

Chlorine count

Bathing load

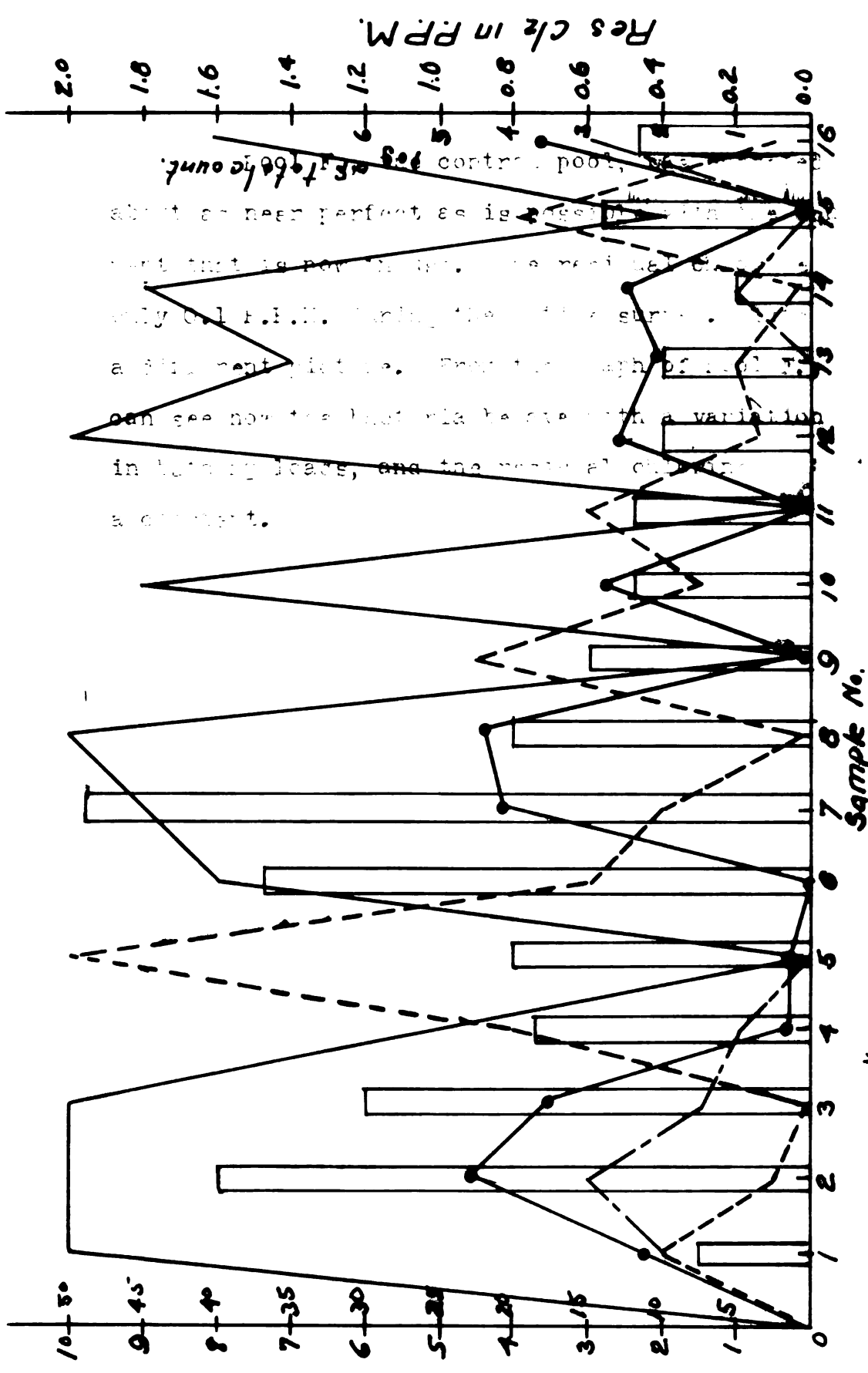
Bathing load
 Chlorine
 Total count
 E. coli
 Streptococci
 µg/l



0 1000

Bathing Load & Tubes showing Streps & coli.

Pool E



- Key
- Streptococcus
 - Esch. Coli
 - Total count
 - Chlorine
 - Bathing Load

about as near perfect as is possible in a swimming pool. The residual chlorine is only 0.1 P.P.M. during the entire summer. This is a slight deficiency. From the graph of residual chlorine you can see how the load varies with a variation in bathing loads, and the residual chlorine is a constant.

Res chl in P.P.M.

Boal Priit 08

2010/11/20

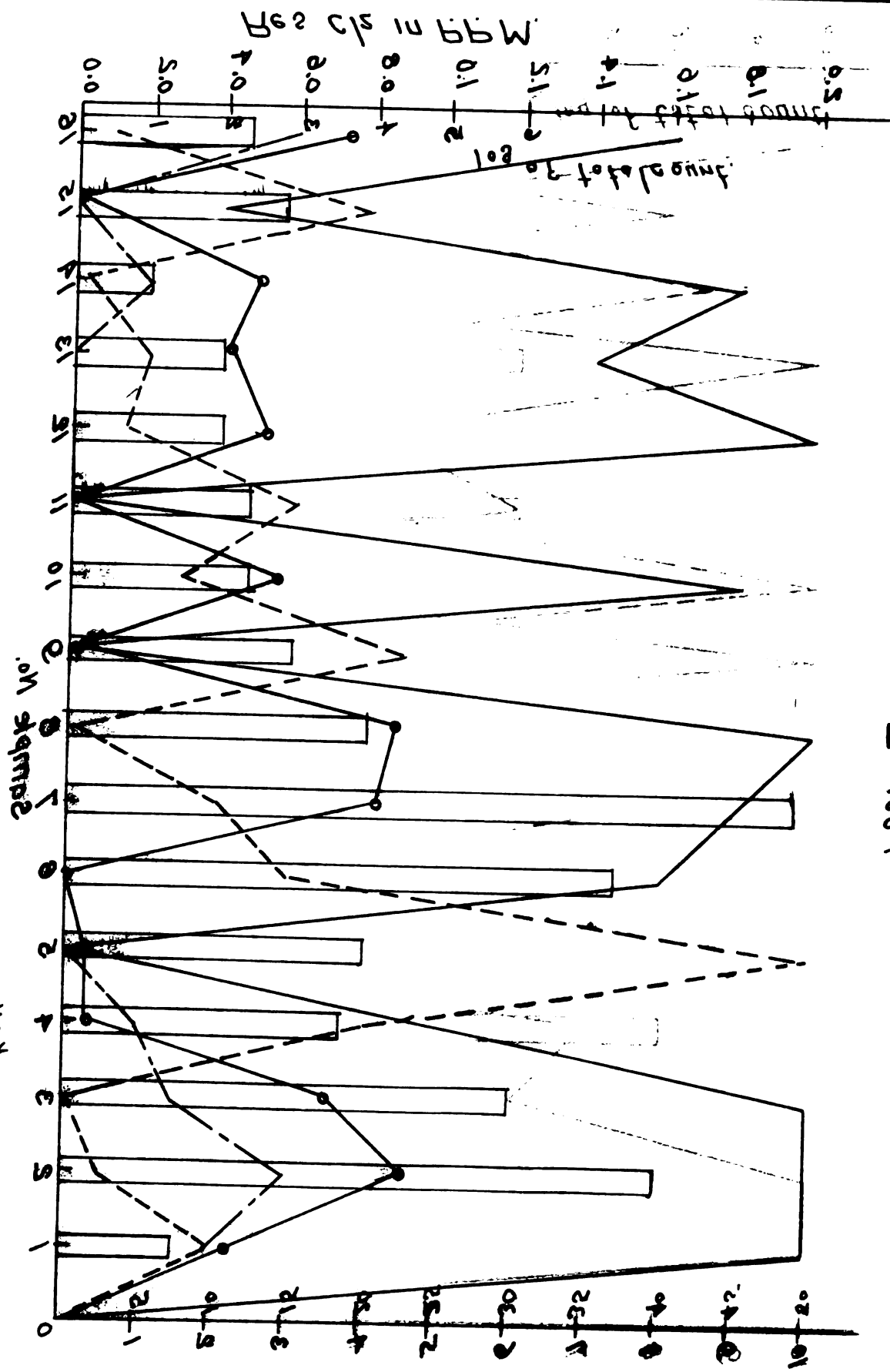
Товарищ

Exp. coll.

2523050592158

467

Bohring 700g & 1m22 2m00m2



1005

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.F.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

all times.

7. met a...

in an careful...

stand...

7. ...

... by the...

the ... of ...

4. That ...

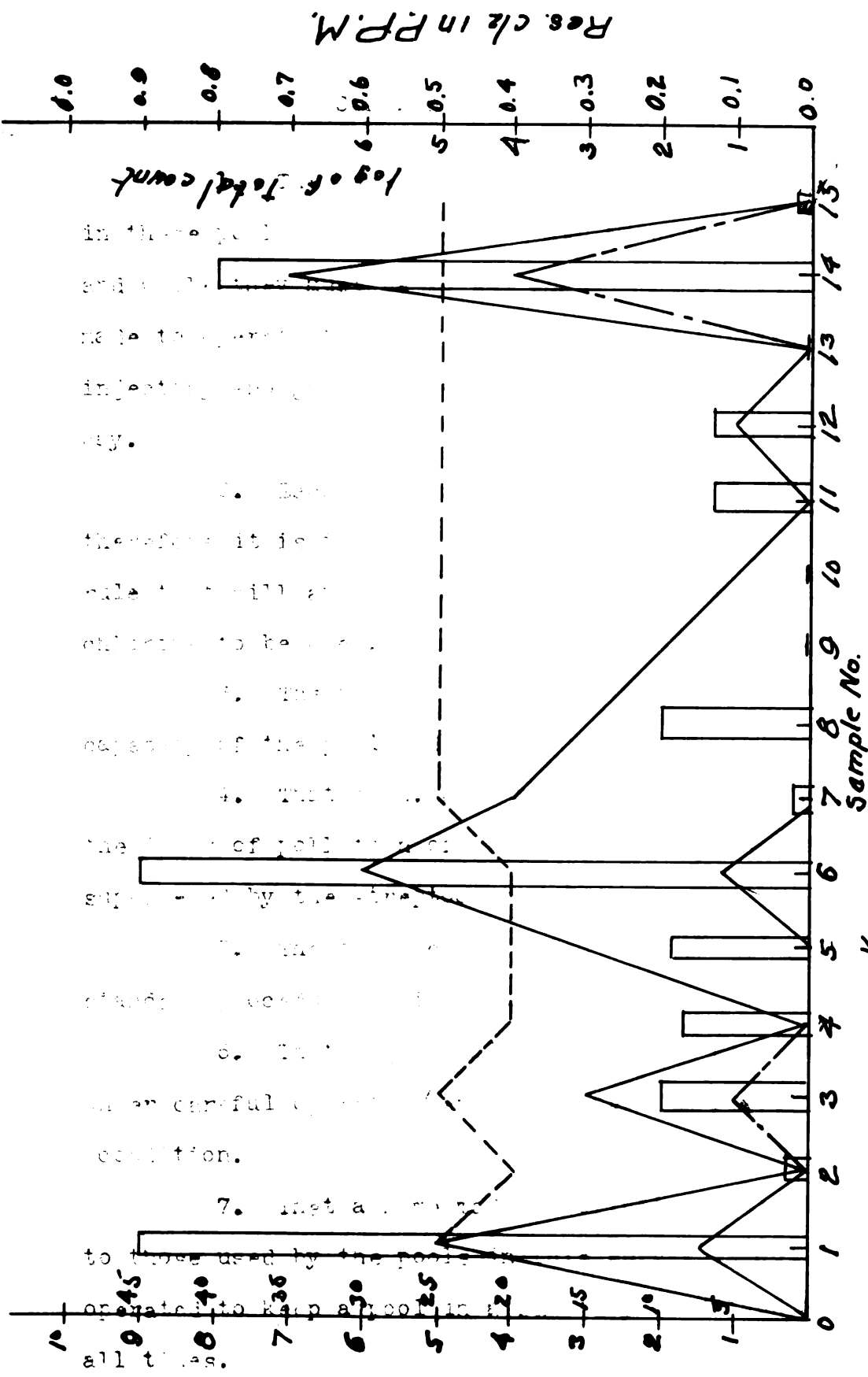
therefore it is ...

1. ...

injecting ...

and ...

in these ...



Key
 Streptococcus
 Esh. Coli
 Total Count
 Chlorine
 Bathing Load

Bathing load

Chlorine

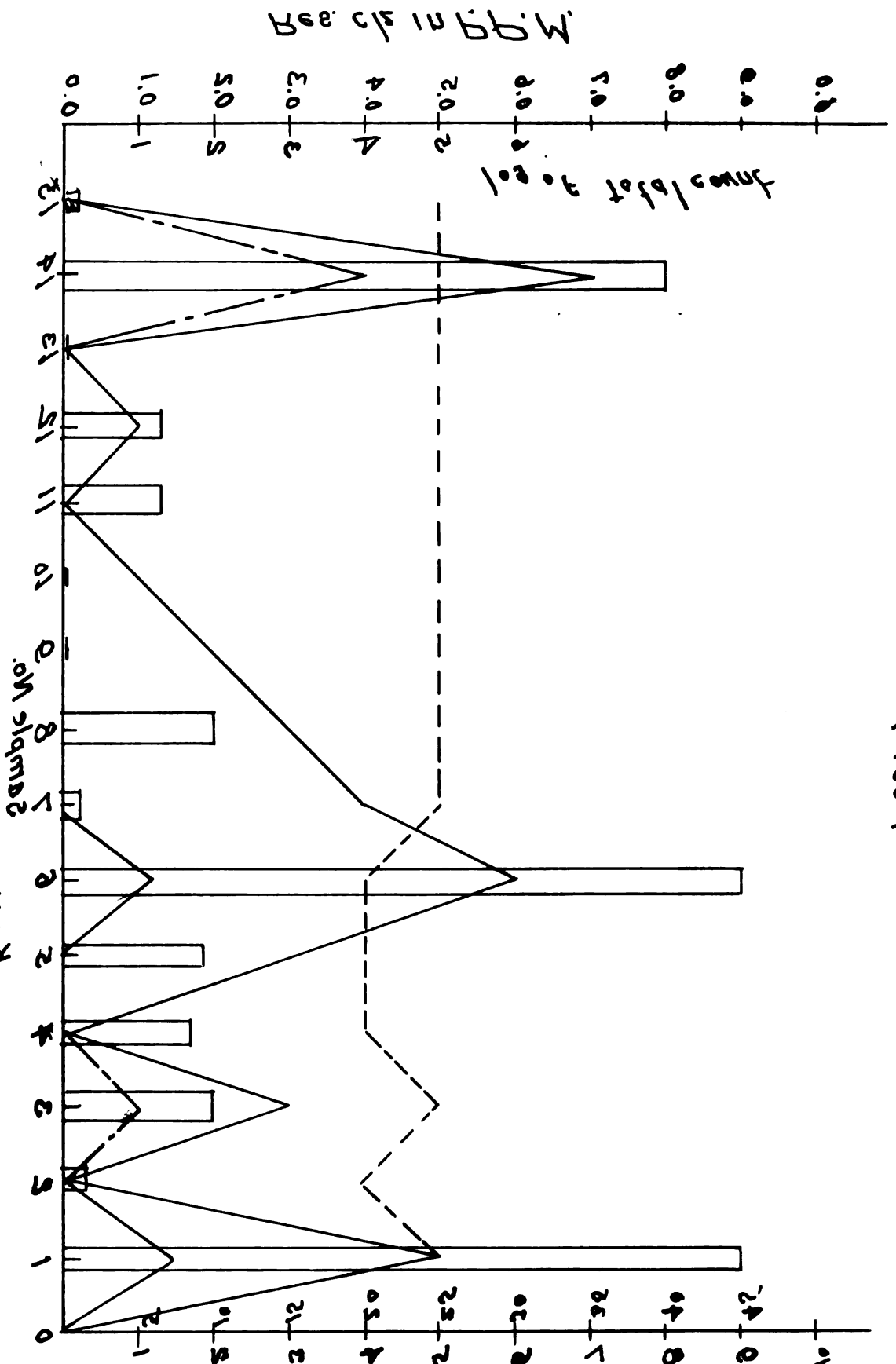
Total count

E. coli

Streptococci

Yes

Plot of total count & bacterial load



7/10/9

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. Maintenance 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

Jun 12 '31
Feb 15 '41

AUG 17 '55

Aug 31 '55

ROOM USE ONLY

Sep 13 '55

Sep 26 '55

Oct 7 '55

