Oklahoma Agricu'tural Experiment Station,

STILLWATER, OKLAHOMA

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THE WATER SUPPLY

BACTERIOLOGICAL EXAMINATION OF WATER FROM PONDS, TANKS, AND CISTERNS.

INTRODUCTION.

This work was undertaken in order to obtain data that would show the relative number of bacteria in water from ponds, tanks and cisterns when examined under conditions similar to those existing when the water is in use. Incidentally the results obtained by analyzing the water from ponds A and B illustrate the rapidity with which small bodies of water, such as stock ponds, purify themselves after heavy rains.

The pond is at present and will continue to be the chief source of water for a great many of the farm animals of Oklahoma, consequently any information concerning the character of water they furnish or that will enable one to obtain better water from them, will serve a large number of interested parties. The pond as seen in most pastures is not kept under the best conditions possible, as it usually consists of a shallow pool of water to which the stock have free access at all times. In many cases it is situated where plowed dirt is carried into it by heavy rains, partially or completely filling it up, and the stock tramping the banks down soon completes the process. Stock standing in the pond soon foul the water with excrement, and in hot weather when the water is low, such a pond is certainly not a very satisfactory water supply. During the winter and spring months when the rainfall is abundant, this condition is not so noticeable as the water is being continually changed by fresh water running in.

The large number of bacteria found in the water from pond A indicates that it is such a pond as described above as well as one receiving a large amount of organic matter washed in by surface drainage. The presence of large numbers of bacteria in water will always indicate a large amount of organic material as this is necessary in order to furnish food for the bacteria to live upon. One of the dangers that follows letting stock of all kinds stand in the ponds is that when the water is at a low stage, and foul as it becomes in the summer season, the cattle will not drink a sufficient quantity of the hot foul surface water to prevent certain derangements of the digestive system such as impaction, "dry murrain," and other conditions that are usually ascribed to dry feed, but which are, in a large measure, brought about by insufficient water.

This work was divided into two periods, the first one of twenty-five days and the second running for nineteen days, with an interval between of five weeks. The object was to secure results from one period with a considerable rainfall to compare with those obtained during a second period when the rainfall would be much less but with other conditions approximately the same. It was also desired to have the work extend over a sufficient period of time so that the comparisons made between the ponds and the tanks would be of some value as indicating the purity of water from these sources. However, the rainfall during the second period was such as to prevent getting the comparison desired. The first period extends over the time when rains are usually abundant, with a rainfall of 4.8 inches for the period. The rainfall for the second period was 3.11 inches which was considerably under the amount for the first period and this difference is noticeable in the difference in the averages for the two periods given at the bottom of tables one and two.

GENERAL CHARACTER OF WATER.

In order to understand the results obtained it is necessary to know something of the general character of the water examined and the conditions under which the samples were taken. The general surroundings of the sources of the water will be described first, after which will be given the manner of taking the samples and making the analysis. The ponds, tanks and cisterns will be referred to by letter in all cases.

Pond A. Figure one shows a photograph of this pond and it is a good illustration of the wrong way to keep them. This pond is situated south of the college barn and receives drainage from the manure piles and feed lots surrounding the barn. Cattle are allowed free access to the pond at all seasons of the year, but other drinking water is supplied.

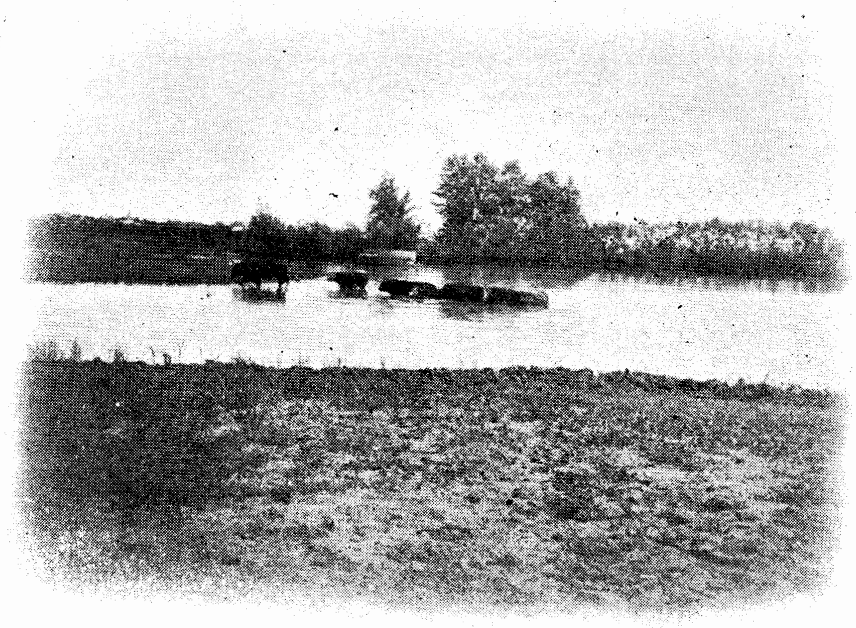

FIG · I--POND A

Pond B. This pond is illustrated in figure two. This photograph shows that the pond is fenced so that cattle cannot stand in the water. The way this pond is kept and the manner of taking water from it is what we wish to designate as the right way to care for a stock pond. Water is piped from this pond to the college barn, a distance of half a mile, it is also furnished to the stock in the pasture in a tank situated below the dam as shown in figure three. This arrangement for supplying water to stock is further described in this bulletin. This pond is supplied with water from prairie sod pasture land and cattle are never allowed to stand in the water at any time.

FIG. 2--POND B

Tank C. This is a steel tank of about ten barrels capacity located in a barn lot. It is filled from pond B and is kept about two-thirds full by means of a float attached to a water valve.

Tank D. This is a public watering trough in the city of Stillwater. This water is practically surface water confined in the bed of a stream and filtered into shallow cisterns from which it is pumped into the water mains of the city.

Tank E. This tank is filled by windmill from a closed well. The tank has a capacity of approximately ten barrels and stock using it consume about one-third of this amount daily.

Tank F. This tank is filled by windmill from a closed well, is of ten barrels capacity and stock running to it will consume approximately three barrels per day.

Tank G. This tank is filled by windmill from a closed well and has a capacity of eight barrels. Stock using this water consume approximately five barrels per day.

Tank H. This is a large shallow wooden tank holding approximately fifteen barrels. The bottom and sides of the tank were partially covered with moss. This tank was seldom full, usually containing four to six inches of water and on several days it was empty.

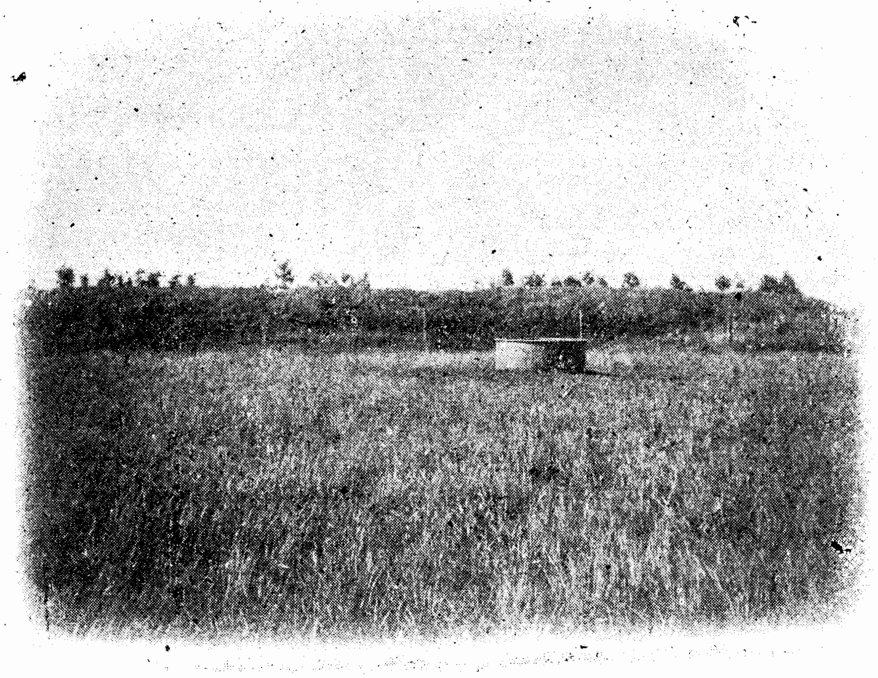

FIG. 3--WATER TANK BELOW POND B

Cistern I. This is a new cistern, filled from a shingle roof, the water passing through a form of screen shown in figure four. A chemical test of this water showed a considerable amount of alkali and this may in a measure account for the low bacterial content. During the second test on account of the presence of one particular kind of germ, the number of bacteria per cubic centimeter (about 20 drops) was much higher than in the first test.

Cistern J. This cistern furnishes drinking water for a large number of individuals and for this reason was carried through the test to see what the bacterial content would be for a long period. This cistern is number 14 in the list of wells and cisterns reported in the examination of drinking water and is fully described under that head.

The water from both ponds, the city water, and that from tank C contains considerable sediment, being such water as is ordinarily found in ponds in Oklahoma. Water from pond B after several days of dry weather contained less sediment than water from pond A under the same conditions. The water from the remainder of the tanks and the cisterns is clear and would be classed as pure water so far as appearances go.

TAKING THE SAMPLES.

The samples of water were collected in the afternoon between two and five o'clock. They were collected in two-ounce sterilized bottles by immersing them half an inch under the surface of the water. The samples from the ponds were taken about ten feet from the shore by fastening the bottle to the end of a pole and reaching out into the pond where the water was not so full of sediment as it is near the bank.

The laboratory work was to determine the number of bacteria in the sample of water and not the kind of bacteria present, as it is very well known that the ordinary water bacteria are harmless and that the number present depends upon the amount of organic matter present in the water. Gelatine plates were used at first but there were so many liquifying germs present in the water that many of the plates were lost on account of the gelatine becoming liquified before the slow-growing water-forms had time to develop. This necessarily made the results unsatisfactory as the great number of blank spaces in the first table will indicate. Agar agar was substituted for gelatine on April 11th and was used for the remainder of the work. The agar plates were kept at room temperature for four days before calculating results from them.

RESULTS OF THE ANALYSIS.

The great number of bacteria found in water from ponds, tanks, etc., is not by any means an indication of the unfitness of the water for stock purposes. In water intended for drinking purposes, the presence of such bacteria as indicate contamination with surface water makes them unsafe on account of the possible danger of typhoid fever and other intestinal disorders being contracted from its use. The presence of such bacteria as indicate surface contamination has no significance when found in water intended for domestic animals as they are not subject to diseases of this character. There are, however, a number of diseases of the lower animals that may be communicated or spread by means of the drinking water, among which may be mentioned hog cholera, swine plague, anthrax, etc. However, with the exception of hog cholera and swine plague, there is very little danger of any of the bacterial diseases of the lower animals being transmitted by means of their water supply. The principal means of spreading hog cholera and swine plague is by running water, and a discussion of water of this kind is not a part of the present bulletin.

The ponds are designated in the tables as A and B, the latter being the one illustrated in figure two. By comparing the results obtained from these ponds it will be readily seen that the one receiving drainage from the barn lots and to which the cattle have free access shows a much higher bacterial content than the one that is fenced and which receives drainage from pasture land. It is also well to notice that the water from tank C has a much greater number of bacteria in it than the pond (B) from which it is filled. The remaining tanks, E, F, G and H are filled from wells and the number of bacteria per cubic centimeter of water is much higher than was found in pond B.

The results obtained from the examination of water from the tanks varies greatly from day to day. This simply means that at times the tanks were only partially full or that pumping water into them disturbed the sediment collected in the bottom of the tank. In the ponds the results are much more uniform, the number of bacteria being high after heavy rains and rapidly falling in number when there were a few days without rain. Two conditions contribute to this purifying process in ponds, sunshine and sedimentation, the latter having a much greater influence in purifying the water than the former. It is well to notice that the purifying process in the pond that is fenced so that the water is not disturbed by stock is such that the actual number of bacteria present in the surface water as shown by the averages is less than was found to be present in some of the wells examined.

The number of bacteria per cubic centimeter in the tanks is, of course, much higher than it is in the wells from which they are filled. On two days samples were taken from the wells from which tanks F and G were filled, with the following results. For the two days, tank F averaged 27,360 bacteria per cubic centimeter of water, while the well from which it was filled gave an average of 4,242 per cubic centimeter. In the other tank tested the average for the same time was 216,575 bacteria per c. c., while the well from which it was filled gave only 4,490 per c. c. It will be seen from this that any water, however pure, when pumped from a well will soon show a large number of bacteria when sampled from a tank, on account of the trash, dirt, etc., that will accumulate in the tank as well as from the saliva of animals drinking the water.

Of the two cisterns included in the test, one (J) is described in connection with the work on drinking waters making it unnecessary to further describe it here. The other cistern (I) is new and was filled a few months before the tests were begun but it had been in use but a short time. The results obtained from this cistern as given in the first table indicate an unusual degree of purity as the average number of bacteria per c. c., for eighteen tests was only 98. Just before the beginning of the second test, a small quantity of water had been run into the cistern which would account for the slight increase of bacteria found up to June second. On this date a large number of red colonies developed, there being practically no other kind present. This particular germ was very abundant during the remainder of the test and is the cause of the high average in the second table.

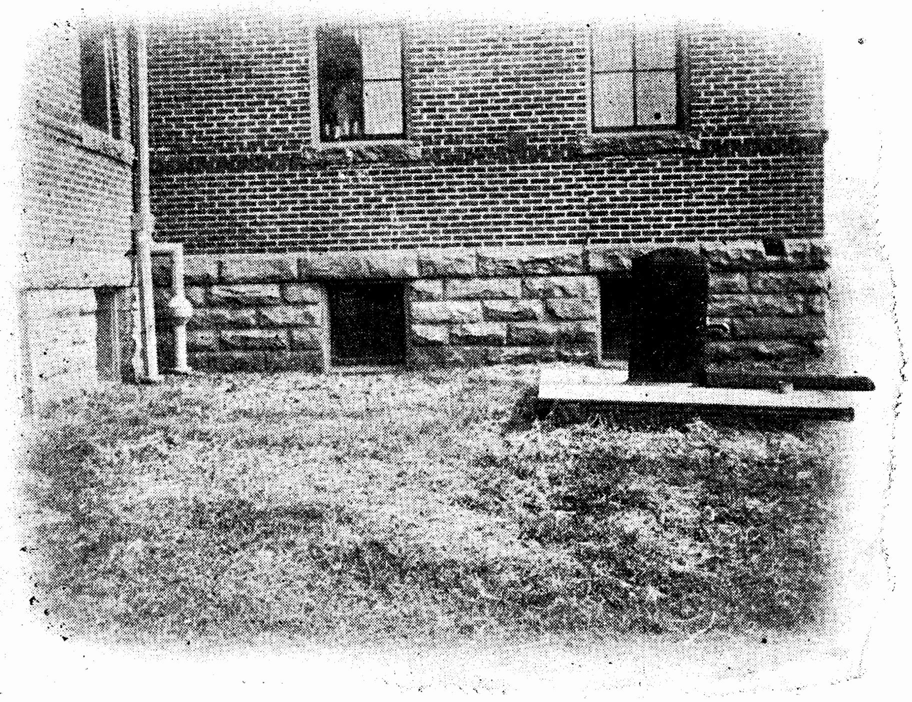

FIG. 4--CISTERN I

One source of danger in the use of any pond water is usually overlooked because it does not appear as a direct loss to the stockman and, like other troubles growing out of insufficient or bad water, it does not appear as an epidemic. Most of the intestinal parasites are spread through the agency of drinking water. If any of the stock are infested with worms, the water from pastures collected into ponds soon becomes contaminated with the eggs and larvæ and in this way are transferred to the alimentary canal of other animals where they develop. The loss from parasites is usually in the way of unthrifty and unhealthy stock, but it is a loss that usually amounts to more than losses from some diseases that are generally considered as dangerous.

WEATHER CONDITIONS.

The following notes show the weather conditions for the period of time covered by the tests and will aid in understanding the results, especially those from the ponds.

March 28. Rained 2.9 inches during the night of the 28th. The first samples were collected on the afternoon of the 29th.

April 2. Rained during the afternoon, rainfall of 1.62 inches.

April 5. Rained .06 inches during the night of the 4th.

April 10. Rained 2 inches during the night of the 9th.

April 16. Trace of rain.

April 19. Rained .02 inches during the night of the 18th.

Total rainfall for the period 4.8 inches.

The weather conditions covered by the time of the second test were as follows:

May 27. Rained at 6 P. M., .94 inches.

May 28. Rained .33 inches.

May 29. Trace of rain.

May 30. Showers, .07 inches.

June 2. Rained .68 inches.

June 6. Trace of rain.

June 7. Rained .64 inches.

June 9. Trace of rain.

June 11. Rained .45 inches.

June 12. Trace of rain.

Total rainfall for the period was 3.11 inches.

TABLE NO. 1.

Showing number of bacteria per cubic centimeter in water from ponds, tanks and cisterns.

DATE	WEATHER COND.	A	B	C	D	E	F	G	H	I	J
March 29	Clear	306600	9523	4486					...	...	5793
" 30	"	498964	7012	32450	1957	16890	129592	308850	37180	...	4440
" 31	Cloudy	229380	3460	49680	24771	121125	230566	330225	8025	...	10222
April 1	Showers	140250	6450	253650	1762	79094	179782	253871	3993	...	88275
" 2	Rain	247830	15078	186068	...			...		424	168063
" 3	Clear	1239083	9070	67393		198891	447321	335639	368	66	...
" 4	Cloudy			...	292	44	160	2806	2312	...	...
" 5	Clear	25500	927	16892	...	60750	290700	80	...	43	43021
" 6	"	2160	190	...	...	...	66	8260	...	36	26690
" 7	"			...	...	129600	198000	4945	117	63	...
" 8	"	3798	...	...	...	...	253638	...	35596	76	...
" 9	"	9152		1485	...		...	...	...	47	16463
" 10	"	12815	2041	674	10431	648	...	40	35904	...	...
" 11	Cloudy	14715	3497	...	8491	762652	13597	252815	2729	20	20460
" 12	Showers	12452	2230	...	9306	390925	22116	99890	29079	72	21173
" 13	"	23150	1551	90498	9482	41327	29704	12148	8800	148	27560
" 14	"	31730	2506	684475	4750	87280	6864	119422	4656	60	41180
" 15	Cloudy	16643	2688	1059300	12123	2632	57770	252790	950	67	28952
" 16	"				...	...	...		...	...	...
" 17	"	14751	6193	1128600	9702	12540	25552	1245220	2007	256	21637
" 18	Showers	21856	2640	819000	15510	53460	143100	469800	1760	142	30447
" 19	Cloudy	12231	945	413900	15075	51296	36069	417690	1260	136	27000
" 20	"	14760	2364	103200	2576	5000	283	3686	504	42	13920
" 21	Clear	12850	3254	66330	8459	34965	360	360360	880	34	19019
" 22	Cloudy	11067	2934	16128	6480	24460	18711	35460	1900	32	25287
Average per C. C.		86397	4227	277456	8823	115190	105697	250215	13623	98	33668

TABLE NO. 2.

Showing number of bacteria per cubic centimeter in water from ponds, tanks and cisterns.

Samples are from the same sources as in Table No. 1.

DATE.	WEATHER COND.	A	B	C	D	E	F	G	H	I	J
May 27	Rain	672300	3690	3650						460	16814
" 28	Showers	418860	2678	5049						210	12845
" 29	Cloudy	130229	4196	27540		2497	890	23474	2978	195	6006
" 30	Showers	16275	1743	2743	19800	514	678	567	8803	120	6184
" 31	Clear	11395	1548	3406	82080	4116	7704	50875	5060	442	8643
June 1	Cloudy	7640	1144	3984	447525	2911	2052	164250	1360	506	1496
" 2	Rain	26928	4488	4600	15093	3108	1545	153800	2236	1800	8404
" 3	Clear	15000	1852	1874	9768	136080	1218	580	1518	55	2166
" 4	Clear	8683	1161	10510			553	561	1287	442	4675
" 5	Clear	8300	833	1210	68458	6600	5000	226800	23832	8762	5141
" 6	Cloudy	9570	1354	5439	68875	10344	3382	60030	5175	43654	6595
" 7	Rain	11482	3614	16164	52785	52360	38560		139590	71955	11242
" 8	Cloudy	10950	1434	6090	13950	56000	8783		10472	4305	34276
" 9	Cloudy	4138	2819	11874	25207	21360	43621	25368	356480	10593	18975
" 10	Cloudy	3804	1984	18900	1540	56320	59850	439968	95737	810	23320
" 11	Rain	32912	3192	31266						155	26000
" 12	Clear	12933	1360	5968	15730	42428	72216	81471	72000	6191	50996
" 13	Clear	11340	8914	105704	30560	18426	24924		3891	870	15312
" 14	Clear	4851	4114	11035	5370	27489	5500		37747	1050	53476
Average per C. C.		74610	2743	14579	61190	29370	20376	102063	27952	8030	27714

A STUDY OF A FEW REPRESENTATIVE SOURCES OF DRINKING WATER.

INTRODUCTION.

A bacteriological study of a few of the wells of Stillwater was made for the purpose of determining the amount of contamination the waters are subjected to by way of surface drainage. The wells studied were chosen for their particular location, taking those most susceptible to, and those least likely to receive surface drainage. Attention was also paid to the open as compared to the closed well. Those wells suspected of being the worst possibly located were those situated in the draw, while those suspected of being the best were those located on the highest ground.

In order to determine whether a well receives surface contamination it is necessary to compare its bacterial content before and after a heavy rainfall. Consequently the dates chosen, as indicated in tables 3, 4 and 5, were dates immediately following a prolonged dry spell or a heavy rain.

A well receiving surface drainage is not necessarily a dangerous well. The fact that many of the wells in the table show a bad condition of affairs in this respect, and no cases of typhoid fever or allied diseases have been contracted by the users of these waters in the past year, simply reveals the fact that in obtaining the drainage from the surface, these wells received none of those bacteria that can cause the above mentioned diseases. If the typhoid fever germ, for example, had been deposited with excretory material coming from one suffering with typhoid fever, near any of those wells, it would have been washed into the well and rendered that water extremely dangerous.

Without doubt, a majority of typhoid fever epidemics are caused by the water supply becoming infected with typhoid excreta or typhoid urine.

Ithaca, N. Y., suffered an epidemic as recent as March, 1903, where 912 cases with 58 deaths occurred, 26 of the deaths being among the students at Cornell University, caused by the pollution of the city water by the excreta of one man suffering with typhoid fever.

Palo Alto, Cal., suffered an epidemic of typhoid fever in 1903, that was traced to one patient suffering with typhoid fever who deposited his excreta on the ground where the rains washed it into a spring used by a dairyman below for rinsing his milk cans. Enough of the water clung to the inside of the cans, to introduce typhoid fever germs into the milk and to thus spread the epidemic.

RESULTS OF ANALYSES.

The following tables are self explanatory to the bacteriologist but a word of explanation is given for those unfamiliar with the bacteriological vocabulary.

The wells, for evident reasons, have been assigned arbitrary numbers, well number 7, for example, stands for the same well throughout, and the tables show that it was sampled on several dates. On Oct. 13, 1903, it was found to contain 100,000 germs per c. c., (about 20 drops); 30 liquifying germs per c. c.; and the Bacillus Coli communis. The germs called liquifiers are those capable of decomposing organic material and their presence in large numbers indicates the presence of dead and decaying plant or animal tissue. Bacillus Coli communis is the germ present in the alimentary canals of all animals, including man, the domestic animals, fowls and birds. Its presence in water indicates that that water has received the excreta from some animal. If of human origin, it is extremely dangerous, not because this germ causes any disease, but because the human being whose excreta is reaching the well may contract typhoid fever and then the germ of that disease will also reach the well. The typhoid fever germ can only pass from the sick to the healthy by way of the excreta or the urine of those suffering with it. The mere presence of large numbers of germs in water would not condemn the water, necessarily, as may be inferred from the above, but boards of health of large cities make it a rule to condemn all water containing over 1,000 bacteria per c.c., not because the 1,000 germs are harmful, but because pure water contains far less and only contaminated water can contain this number. The presence of B. Coli always condemns a water for the above reasons.

This is the point to be remembered. The colon germs do not create disease, nor are the liquifiers dangerous, but their presence is an indication of what is reaching the drinking water supply, and should serve as a danger signal.

TABLE 3

TO SHOW THE NUMBER OF BACTERIA PER CUBIC CENTIMETER.

Date	Oct. 13 1903 (wet)	Mar. 17 1904 (dry)	Apr. 13 1904 (dry)	Jun. 22 1904 (wet)	Aug. 22 1904 (wet)	Oct. 15 1904 (dry)	Feb. 20 1905 (wet)	May 29 1905 (wet)
No. 1.	....	....	....	....	1393	3200	frozen	116707
No. 2.	....	....	9000	....	7400	15250	56740	79200
No. 3.	....	....	80	....	16980	3487	6430	2971
No. 4.	....	....	159	....	70	110	9	187
No. 5.	....	....	102	....	945	1300	13	252
No. 6.	....	....	....	....	303	169	1365	1302
No. 7.	100000	1280	....	....	68520	42840	6000	21285
No. 8.	321	16	....	165	226	48	10	286
No. 9.	202	200	....	165	2233	321	2450	4289
No. 10.	1505	39	....	3050	3297	1110	4140	17010
No. 11	1586	208	2907	....	3800	225	4800	700
No. 12.	1221	164	....	325	3960	178	frozen	5760
No. 13.	....	....	....	....	400	3980	4800	3332
No. 14	313	....	2620	692	9466	142	....	....

TABLE 4

TO SHOW THE NUMBER OF LIQUIFYING BACTERIA PER CUBIC CENTIMETER

Date	Oct. 13 1903 (wet)	Mar. 17 1904 (dry)	Apr. 13 1904 (dry)	Jun. 22 1904 (wet)	Aug. 22 1904 (wet)	Oct. 15 1904 (dry)	Feb. 20 1905 (wet)	May 29 1905 (wet)
No. 1.	....	....	....	....	202	160	frozen	918
No. 2.	....	....	100	....	26	1000	*	990
No. 3.	....	....	10	....	142	20	20	0
No. 4.	....	....	11	....	2	6	1	44
No. 5.	....	....	32	....	55	400	1	89
No. 6.	....	....	....	....	47	120	161	168
No. 7.	30	44	....	....	2000	16	50	561
No. 8.	74	2	....	21	78	5	4	22
No. 9.	32	10	....	3	115	71	125	178
No. 10.	.. 235	14	....	120	158	50	700	105
No. 11.	49	15	97	....	860	74	44	575
No. 12.	400	12	....	60	170	85	frozen	156
No. 13.	....	....	....	....	40	327	1890	224
No. 14.	148	....	*	20	88	41	....	....

TABLE 5

TO SHOW THE PRESENCE OF BACILLUS COLI COMMUNIS, WHICH INDICATES FECAL CONTAMINATION.

Date	Oct. 13 1903 (wet)	Mar. 17 1904 (dry)	Apr. 13 1904 (dry)	Jun. 22 1904 (wet)	Aug 22 1904 (wet)	Oct. 15 1904 (dry)	Feb 20 1905 (wet)	May 29 1905 (wet)
No. 1.	....	....	....	....	X	X	frozen	-
No. 2	....	....	-	....	-	-	-	X
No. 3.	....	....	-	....	-	-	-	-
No. 4.	....	....	-	....	-	-	-	-
No. 5.	....	....	-	....	-	-	-	-
No. 6.	....	....	....	....	-	-	X	-
No. 7.	X	-	....	....	X	-	-	X
No. 8.	-	-	....	-	?	-	-	-
No. 9.	-	-	....	-	X	X	-	X
No. 10.	-	-	....	X	X	-	-	X
No. 11.	-	-	-	....	-	-	-	-
No. 12.	-	-	....	-	X	-	frozen	-
No. 13.	....	....	....	....	-	-	-	-
No. 14.	-	....	-	-	-	-	....	....

Blank—No sample taken. X—positive. ?—doubtful. *—Many. - —negative.

METHODS USED.

The methods used in the laboratory for the detection of the numbers and kinds of bacteria were those ordinarily used in bacteriology and are those recommended by the American Board of Health Association. The total number of bacteria per cubic centimeter (about 20 drops), and the number of liquifiers per cubic centimeter were determined by the gelatine plate method, using 12 per cent neutral gelatine and incubating at 15 to 20 degrees C. for from 4 to 7 days. The colonies were counted at the end of that time by means of a hand lens, and from this was calculated the number of bacteria per c.c., for the sample.

The presence or absence of B. Coli communis was determined by several methods, so that one could act as a check on the others. Where all methods gave negative results the absence of B. Coli was recorded, but if any one of the tests gave positive results, the presence of B. Coli was recorded.

Glucose fermentation tubes were used and where the gas formula was H:CO2::2:1, the germs were isolated and studied in pure culture for the identification of the colon germ.

Litmus lactose agar plates were made, incubated at 37 degrees C. and the number of acid colonies determined. The acid forming germs were then studied in pure culture for identification.

Glucose-free broth was used for the detection of indol production and always checked up the results when the other tests were negative for B. Coli.

Carbolated dextrose broth, as described by Gage in the Journal of American Medicine, Vol. IV, No. 8, was used as another test for B. Coli. When gas is produced in this medium it is almost a certain indication of the presence of B. Coli. And in case gas was produced, in the course of our work with this medium, the germ was isolated in pure culture and studied for its identification with the colon germ.

No effort was made to determine the number of B. Coli per cc., in a given sample, other than a count of the acid colonies appearing on the litmus lactose agar plates. This is not essential, however, the question is not how many, but are the colon germs present in a given water. If they are present at all they have reached it by some means which indicates pollution.

SOURCE OF SAMPLES.

The following is a description of the various wells indicated by number in the tables, and also a description of the weather conditions on and before the dates upon which the samples were taken.

Well No. 1.—An open well provided with a suction pump, located in the bottom of a draw on the outskirts of the city. The pump simply extends into a hole in the ground from which water can be pumped. The water is always turbid, the degree of which depends upon the frequency of the rains. In other words, this well contains nothing but surface drainage, as the tables indicate. There are no buildings within 20 rods of this well, the colon germs present coming from the excreta of cows allowed to stand around the well in the mud.

Well No. 2.—An open well provided with rope and bucket, located in the draw on the outskirts of the city. It is in close proximity to the dwelling house and but a few feet from the outbuildings. Water stands about 10 feet below the surface in this well. B Coli. was found in it on one date.

Well No. 3.—An open well provided with rope and bucket, located on the side of the slope leading to the draw. It is within 15 feet of the dwelling house, but the surface of the ground around is in a clean condition and slopes off to the outbuildings 100 feet away. Water stands in this well about 15 feet below the surface. Although this well is in danger of receiving surface drainage, it has not received the colon germ up to this time.

Well No. 4.—A closed well provided with a suction pump and located on the side of the slope that leads into the draw. It is close to the dwelling house, but 100 feet away from the outbuildings and on higher ground. The water from this well has always been excellent and apparently has received none or very little surface drainage.

Well No. 5.—A closed well provided with a suction pump and located on the ridge above the draw. It is within 15 feet of the dwelling house but is higher and 100 feet away from the outbuildings. This well receives very little drainage.

Well No. 6.—An open well with rope and bucket and located on the ridge above the draw. The well is within a few feet of the dwelling house and adjacent to the chicken house, but about 75 feet away from the outbuildings and on a level with them. This well receives some surface drainage.

Well No. 7.—An open well with rope and bucket located on the high ground. It is only 15 feet below the surface of the ground and badly located as to barns and outbuildings. It receives much surface drainage and has nearly always shown the presence of the colon germ.

Well No. 8.—A closed well provided with a suction pump and located on high land in the central part of the city. It is surrounded with barns and all the filth of the barn yard. It is, however, a 60 foot well and securely closed, which accounts for the little or no drainage that it received. This well must represent the very best type of a well. Surrounded by such filth and yet receiving none of it speaks well for its construction.

Well No. 9.—A closed well with a suction pump and located on high land in the very center of the city. It is within 15 feet of a large privy vault and a cess pool, and receives contamination from these sources as the tables show. B. Coli is generally present.

Well No. 10.—A closed well with a suction pump, located in the main street of the city on high ground. It is a 30 or 40 foot well but has always been badly contaminated. The colon germs probably find their way into the well from the horse manure in the street around it.

Well No. 11.—A bored well with pump, located on high ground in a public school yard. It is 100 feet away from the outbuildings and receives none of the drainage from that source. It does receive much surface drainage and is very turbid after a heavy rain.

Well No. 12.—An open well with rope and bucket, located on high land and away from the outbuildings and higher than them. This well receives surface drainage, but being removed from filth sources it does not receive dangerous material.

Well No. 13.—An open well with rope and bucket, located on high ground in the central part of the city. The surface of the water is 20 feet below the surface of the ground. It is 40 feet away from the dwelling, 60 feet from the outbuildings and on a level with them. The water receives surface drainage, but none from the outbuildings as evidenced by the absence of the colon germ each time the sample was taken.

No. 14 is a cistern located on the college campus. This represents the source of drinking water for a large per cent of the people of this city. It is a water supply that is the least subjected to contamination.

The water flowing off from the roofs, especially after the roofs have been allowed to wash thoroughly, must represent the purest of water. It is true that the colon germs may be found, due to the deposition of excreta by pigeons and sparrows, but it cannot indicate a danger of typhoid fever. This sample was placed among the others for comparison. A cistern faultily constructed and allowed to receive, in addition to the water from the house tops, the surface water from the surrounding soil, allowed to become the repository of children's playthings, dead mice and bugs, becomes doubly dangerous and far less desirable than any of the above described surface wells. The cistern never loses what it catches whereas a well will eventually purify itself if the contaminating influence is removed. But a well constructed, vermin-proof cistern, filled with rain water from a clean roof will represent the source of the purest drinking water.

Wells and cisterns must be so constructed and protected that the surface water will not find its way into them, before a pure and wholesome drinking water can be insured.

WEATHER CONDITIONS.

October 13, 1903.—The first date upon which samples were taken was the end of a three days' rain, during which time 1.1 inches of rain fell.

March 17, 1904.—After a long dry spell extending over several months. On the second of March, one of the worst dust storms in the history of the Territory occurred.

April 13, 1904.—After a continuation of the dry period. Practically no rain fell since January of this year. On April 9 another dust storm occurred.

June 22, 1904.—This date represents a time after much rainfall. 7.28 inches fell during May, and nearly 4 inches so far this month. No rain fell directly previous to this date, the last one of any importance was on the 4th.

August 22, 1904.—During the rainy period. The night before it rained 1.1 inches, while on the 17th, 18th and 19th, it rained 2.79, 2.05 and .64 inches respectively.

October 15, 1904.—On the 14th it rained .09 inches, while previous to that time no rain fell during the month. This date represents a dry period.

February 20, 1905.—This date represents the end of a period of cold and snow. Snow has been on the ground for some time, thawing and freezing alternately. Upon this date the snow was melting rapidly and gave practically the same conditions as a rain.

May 29, 1905.—This date marks the end of a wet season. It rained every day for ten days preceding this date.

The tables contain the words, (wet) or (dry) after the dates representing the condition of the weather at the time of sampling and the days preceding.

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BUILDING THE POND.

A pond that is to furnish drinking water for stock should be fenced and the stock kept out of the pond and allowed to drink from a tank supplied with water from the pond through a pipe under the dam and leading to the bottom of the pond. In building a pond, one of the first steps is to place the pipe that is to conduct the water from the pond to the tank where the stock is to drink. This pipe should be put into the ground about two feet and extended twelve or fifteen feet beyond the line where the bottom of the dam will come on the inside. Special pains should be taken to pack the dirt well in the trench around the pipe, for if this is not done, water is very likely to seep out under the dam through this ditch and a seep like this, once started, is almost impossible to stop. An inch and a quarter pipe should be used for the above purpose. On the end in the pond, an upright piece of pipe that will extend two or three feet above the bottom of the pond should be attached. A substantial screen of some kind should be put over the end of the upright pipe. A cast guard the same as used on the bottom of a pipe in a well is good for the purpose but should not have the guaze screen inside that is commonly used in the well. The guard may be wrapped outside with coarse galvanized wire screen. It is well to further protect this outlet pipe and screen by setting four posts in a square around the pipe and about two feet from it. Coarse wire screen may be used to enclose the space between the posts, or old boards may be put on if good sized cracks are left. This will prevent the outlet from being covered so soon when the conditions are such that the pond fills in with the wash brought down with the water. The pipe should extend twenty to thirty feet outside of the dam to enable placing the watering tank away from the soft, seepy ground that is often found just below the dam. It is well to put in a cut off valve near the tank.

After the form and location of the base of the dam has been determined, the area of it should be plowed. If this soil is full of roots or covered with grass, it is best to scrape it off as deep as the plowing and plow up the area again, leaving the base loose and rough before dirt for the bank is put down. This will aid in preventing seeping at the bottom of the dam. To make a good strong embankment for a pond the sides should slope about 45 degrees or in other words one to one; one foot in width to every one in height. If the labor is not very expensive and other work not crowding, one and one-half to one will be a better pitch for the bank, particularly on the slope on the inside of the pond. The top of the dam should be three to four feet wide and after the dam has settled, one to three feet above the level of the pond when full. The height of the top above this level should be such that the water will not go over the dam during a freshet except at the spillway, as that is what washes many dams out. The necessary height of this will depend upon the size of the spillway and the volume of the water going into the pond at any time. When figuring on the height, allowance must be made for the embankment settling six to ten inches where the bank is eight to twelve feet deep. In building up the embankment, the dirt should be put on in uniform layers regularly placed, keeping the bank about level. This will insure more uniform settling or packing of the dirt and the dam will not be as apt to leak. While the embankment is new, it is easily washed down on the inside of the pond by the waves. In a few months, half of a good sized dam has been cut down and washed back into the pond in this way. It is true that this washing down by the waves continues year after year, so the inside of the dam should be set to Bermuda grass and water sedges and willows at once. But to protect the bank until the willows and grass get a start, it should be riprapped with brush or old boards if possible. The Bermuda grass will make a fine covering for the top and outside of the dam as well and should be put on when the dam is built.

The spillway or over-flow should be large enough to insure the water in the time of a freshet being taken care of without going over the top of the dam. Where possible, the spillway should be on the undisturbed soil so as to prevent as much as possible washing out. Wherever placed, it should be well sodded down with Bermuda grass or some other plant that will bind the soil and keep it from eroding. Where ponds are located below cultivated fields considerable difficulty will be experienced because of the soil washing in and filling up the pond. Such trouble can be obviated to a large degree by so building the pond that the spillway will be at the back end of the pond where the water enters it. This can be done by extending wings out on either or both ends of the dam. A pond so constructed does not allow the current of water carrying the wash to flow into the pond and deposit the dirt there. Instead, the current flows around the pond and carries the sediment with it or deposits it at the mouth of the pond where it does no harm. It is this dirt and sediment going into a pond all the time that helps to make the water impure and fills up the pond shortly. Another help in keeping the wash from going into the pond is to force the water out into a wide shallow stream in some way before it enters the pond or in any way reduce the force of the current which will cause most of the material carried in the stream to be deposited before it enters the pond. A good heavy growth of weeds, grass, sorghum, or brush at the head of the pond will bring about the above result in many cases. Again, one or more small ponds above the large pond to be used out of will keep the pond proper from filling up, at least as rapidly as it otherwise would.

Generally the pond should be fenced as soon as completed and all stock kept out. Occasionally where the soil is of a sandy, porous nature, it is well to let stock run into the pond for a year or two in order to help puddle the bottom and make it hold water better. Frequently the banks need a little additional tramping to what they received while being built in order to settle them properly and the stock running on them will do this. The pond fence should be such that it will turn all kinds of stock including little pigs if the pond is near the barns. It is advisable to leave quite a margin between the pond and the fence which can be set to trees. In such a location, the trees will make a fine growth.

In locating a pond, many think that it must be in a ravine where a torrent of water runs when it rains. Really a better place is where there is a gentle swale in the field. It may require handling a little more dirt in building in the latter place, but it will not be as apt to fill up and can be better controlled. By taking the dirt out of the bottom to make the banks with, a good deep pond can be made which is a desirable feature.

The watering tank should be supplied with a float valve so that the tank is kept full at all times. For such a place, an eight or ten barrel tank is large enough.

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BUILDING THE CISTERN.

INTRODUCTION.

The bacteriological examinations of the water from wells reported in this bulletin show how unsafe from a sanitary standpoint wells may be. Contamination of the water of wells will increase instead of diminish and it is increasingly necessary that some other source of water supply be provided for drinking purposes. The many chemical analyses of well waters from every section of the territory which have been made by the station show that the ground water is very variable in the amount of dissolved mineral matter which it contains. This often makes the water unfit for drinking. The cistern, properly constructed and cared for, furnishes a means of providing pure water for human use, just as well constructed and properly protected ponds furnish a good source of water for stock purposes.

LOCATION.

In the nature of the case, a cistern will be located near to the kitchen and often, will not be thought of until after the house is built. It is of much advantage to have the cistern where it will be in the shade either of trees or buildings. But it is important that it may be easily cleaned and for this reason, it is not desirable that the cistern be under the house. It is convenient to have the pump on a porch and where so located, the cover of the cistern should be tight, but removable, and may form a part of the porch floor.

CONSTRUCTION.

It is well to employ a mechanic when building a cistern but it is not at all necessary to do all of the things he may want to do. The excavation for the cistern should be carefully made, the sides being shaved down regularly. It should be deep and of ample size. A circular cistern six feet in diameter and twelve feet deep will hold a little over one hundred barrels and this should be the minimum size. Each additional foot in depth increases the capacity about eight and one-half barrels. A cistern ten feet in diameter and twenty feet deep will hold about four hundred and seventy-five barrels.

In some localities, the soil is of such character that the cement plaster is applied directly to the soil. While many cisterns thus constructed are satisfactory, more are faulty. It is as important to keep the soil water from seeping into the cistern as it is to keep the cistern water from seeping out. The safe plan is first to lay in cement mortar a brick bottom, dish-shaped so as to give extra strength. On top of this, a brick wall should be laid up in cement mortar with enough lime in it to make it work smoothly and the space between the bricks and dirt should be filled solid with this mortar. The arch should be laid up in cement mortar and the neck of the cistern should be long enough to permit of considerable filling in with soil, both for drainage and insulation from heat. The inlet pipe and the overflow pipe provided with a screen to keep out insects should be cemented in at the proper height in the neck of the cistern. These pipes should be of glazed tile of the same size as the downspout from the roof. The entire interior of the cistern should be plastered with a heavy coat of cement mortar well worked down and after setting, this should be brushed with cement and water so as to fill the pores and give a smooth surface. Only fresh Portland cement should be used.

FILTERS.

During the construction of the cistern, the mechanic will in many cases insist upon building what he calls a "filter." This takes many forms. It may be an arch of brick over the dish-shaped bottom with a hole left for introducing the cylinder of a pump, the pipe to be cemented in afterward. Or the "filter" may be a brick partition across the cistern, the water to be introduced on one side and taken out on the other. Or it may be a sort of chimney built up in the middle of the cistern in which the pump is to be placed, the water being run into the cistern outside of the chimney. Don't let him do it. A cistern should be a water-tight receptacle provided with pipes of tile for the inflow and overflow and a contracted neck which may be fitted with a covering to hold the pump. When built in this manner, it may be cleaned and kept clean. Any contraptions placed in the cistern defeat these objects.

ROOF AND DOWNSPOUTS.

Pure water will not come out of a cistern into which filth goes every time it rains. Bird nests must be kept out of the gutters. Birds will give notice of their presence and it take but litle time to keep the gutters clean. The downspout from the roof should be fitted with a cut-off about five feet from the ground and a suitable pipe, preferably of tile, to carry away the waste water. The other pipe from the cut-off should be connected with a cleanable screen made of two or more gauzes of fine brass wire which will prevent all particles except very fine sediment from being carried into the cistern with the water. One form of the screen is shown in the corner of the building in Figure 4. The pipe from the screen should be continued to the surface of the ground and connected to the fill-pipe which was cemented into the neck of the cistern. Glazed tile, well cemented at the joints, is best for this purpose.

It will not do to depend on the rain allowed to run away entirely to remove sources of contamination from the water admitted to the cistern. After a heavy shower which was allowed to cleanse the roof, the water was turned into the cistern shown in Figure 4 and another heavy shower followed. After it was over, three dead sparrows were found in the screen. In another instance at another cistern on the college campus, a six-inch centipede was found in the screen after a shower. This shows the great necessity of having some means of keeping filth out of the cistern and of removing it before it decomposes. Any form of outside filter, arranged without a screen between the filter and the cut-off, must act as storage for decaying vegetable and animal matter which will maintain the water of the cistern in a uniform state of nastiness. And any alleged filtering contraptions inside of the cistern are even worse. The outside filter may be cleaned once in a great while; a porous brick wall inside of a cistern cannot be cleaned. A cleanable screen below the cut-off in the downspout and cleaning the screen after every rain is all that is necessary. For those who are unhappy without something called a filter in connection with their cisterns, outside filters between the screen and the cistern are the least objectionable.

PUMP.

There is but one form of pump which is satisfactory for drawing water from cisterns, though it is made in many shapes and designs. The pump shown in Figure 4 is a good kind. The principal feature of these pumps is that they carry as much air to the bottom of the cistern as they take water out. Pumping thus is made to aerate the water and when such pumps are used, there is nothing of the disagreeable taste commonly associated with cistern water when pitcher or cylinder pumps are used.

CLEANING.

Properly looked after, a cistern arranged as suggested will get nothing except fine dust into it and will not need frequent cleaning. The lime from the walls of a new cistern will make the water undesirable for use and after the cistern has been thoroughly soaked, it should be emptied and the entire interior should be scrubbed and rinsed. The second filling will have but little lime in it and usually, the water may be used for all purposes.

But the screen should be cleaned at once every time after allowing the water to run into the cistern and the cut-off should be left turned off after every rain. This will make certain that, while some water may be wasted, the cistern will not be filled with dirty water. After a long period without rain, the roof is covered with dust and dirt which must be kept out of the cistern if good water is to be had.

JOHN FIELDS,
Director.