INTERPRETATION OF THE SANITARY ANALYSIS OF SOME SOUTH DAKOTA WATERS

Alfred N. Cook, Arthur L. Haines, and Orville D. Dunbar

PART ONE

Alfred N. Cook

(Read at the opening of the Chemistry Building at the University of South Dakota in 1915 and subsequently presented before the South Dakota Academy of Science in connection with Part Two.)

During a residence of twenty years in and on the borders of the State of South Dakota, during which time I have personally examined about 200 samples of water from various parts of the State and have supervised the examination of a considerable number more, I have naturally accumulated some data that is not of common knowledge to chemists who live beyond the borders of the State and perhaps to some who live within the State who have not given the matter special attention.

The waters examined were mostly from the southeastern part of the State, but it is believed that the deductions will apply in general to practically all of the territory east of the Missouri River, since it comprises mostly the same geological formation, the alluvial plains of the largest river and the outcrops of earlier formations forming but a relatively small area. What analyses have been made from the upper part of the State seem to be of the same general character. Except in the case of those from river bottoms the samples were all from the glacial drift.

Someone has said that "a water analysis is not an analysis at all." In a sense this is true and the term "water examination," which has been adopted by some of the most experienced analysts, would seem to be more applicable. However that may be, it is certain that no fixed standards of interpretation, even of a very general character, can be adopted for the country as a whole. Failure to recognize this fact on the part of chemists has at times been the cause of endless confusion, trouble, and delay. In few States is this so true as in the State of South Dakota, largely because the State is new and the conditions are not generally known to chemists beyond its borders. The fact

that the constituents of South Dakota waters are much higher than in States farther east is probably due mostly to the fact that the rainfall has been considerably less for many years and the soil has not been so completely leached of its soluble salts. I am told by chemists who have had experience in water examination on the Pacific Coast that in some respects the results of water analysis are far different from those in the eastern States: like South Dakota the ammonia and oxygen consuming power run very high but the chlorides run much lower and the nitrates run higher.

The following sample of water was condemned by a competent chemist of experience (who interpreted his results by eastern standards) on account of the high mineral content, high albuminoid ammonia and high oxygen consuming power. This water could not have been contaminated, because it was not in the neighborhood of any source of contamination and all other conditions were favorable.

Solids	1562.00
Nitrates	.03
Nitrites	None
Nitrogen as free ammonia	.009
Nitrogen as albuminoid ammonia	.171
Oxygen consuming power	8.50

The following report on a series of test wells was made by a chemist of extensive experience and training from one of the larger universities of an eastern State. The report was furnished me by a member of the city council of a South Dakota city seeking a good water supply.

Sample	Solids	Chlorin	O. C. P.	Free ammon.	Alb. ammon.	Nitrites and Nitrates
Missouri River	281.00	6.04	2.87	0.22	0.22	Trace
Well No. 5	2681.00	73.08	2.87	1.26	0.23	Trace
Well No. 6	1686.00	76.63	2.86	0.90	0.31	Trace
Well No. 7	2581.00	20.88	0.88	0.16	0.34	Trace

The chemist says: "The analytical data in the enclosed report show that the four samples of water contain altogether too much chlorine and organic matter. With the exception of the Missouri River sample, they also contain abnormally large amounts of solids.

"Unless there are salt beds or salt waters in the neighborhood, the high content of chlorine arouses suspicion as coming from sewage. The worst feature of these waters is that they contain too much albuminoid ammonia, indicating contamination with organic matter.

"On the basis of these considerations I would condemn all four of these samples of these waters as unsafe for drinking purposes.

"Very sincerely yours,

"______ ______ ______" (Signed.)

It might be said that two other chemists, then located in South Dakota, condemned these samples. They were good analysts no doubt, but the exceptional character of South Dakota waters had not been called to their attention. The writer had made an exhaustive study of the waters of two localities of the State several years before and was prepared for the emergency when called upon to make a personal investigation and re-analyze the waters in question. It will be noted that the Missouri River water is condemned, along with the other samples, on the supposition that it contains sewage. The great cities in South Dakota on the borders of this big stream are presumably responsible for this alarming condition! It is a generally recognized fact by those who live near it that the Missouri River water, when freed from silt and sand, is a very fine, potable water. Like many surface waters some of the constituents are a little high but conditions would preclude the possibility of its being caused by sewage. The content of chlorine of the three wells under suspicion as being contaminated with sewage is lower than the average uncontaminated water in South Dakota, in the experience of the writer. With regard to the free and albuminoid ammonia it may be said that, while the results are a little higher than the average, it is not an infrequent experience to find waters in the State that run very much higher.

The author made a personal investigation of these wells and examined the water in the laboratory, and while the results of the analysis were confirmed it was found

that the wells were so located as to preclude the possibility of contamination. On account of favorable surrounding conditions and the fact that the results of the analyses did not vary materially from the analysis of South Dakota waters known to be pure, the samples were pronounced to be sanitary. Similar instances have come to my notice at various times but these will suffice to show the necessity of using extreme caution when passing upon the sanitary character of waters in this State.

Solids.—There is a prevailing opinion in some quarters that a large amount of solids, say 700 to 1,000, or above, is injurious on account of putting too large a load upon the kidneys. As a result of this opinion many South Dakota waters containing 1500 to 2000 parts of solid matter have been condemned as being unhealthful, and in some instances as being caused by access of sewage. However, it should be noted that many people in our own State are making daily use of water running even higher, and in some cases much higher, than this in total solids with no apparent ill effects. It is no doubt true that waters running high in total solids, particularly sodium and magnesium sulphates, are too loosening to the system for those not accustomed to their use in case of some people, and occasionally persist in causing indigestion, not only of human being but of live stock as well; but as nearly as I can learn, the effect upon the kidneys is a doubtful question. In conferring with health officers and physicians in the two Dakotas I have found but one who believes that kidney trouble is more prevalent in these two States than in the States farther east, where the total solids run very much less. One health officer who has had experience in the East is of the opinion that kidney trouble is less prevalent here.

The ordinary person drinks from one and one-half to two liters of water a day. In the case of water containing 2,000 parts of solid matter a liter one would ingest a maximum of 4 grams of solid matter daily. Considering the fact that in ordinary drinking water one would ingest approximately 1 gram of mineral matter daily this would place an extra load of only 3 grams on the system daily. Considering the amount of mineral matter excreted through the kidneys and other excretory organs daily this would be but a small increase.

Loss on Ignition.—Loss on ignition of course runs very high and is very rarely of value in the interpretation of a sanitary examination.

Nitrates.—I have commonly considered .1 part to a million as the standard for nitrates, and any amount considerably above that figure constituted grounds for suspicion.

Nitrites.—Nitrites, of course, occur occasionally in deep waters and in such cases could not be considered an index to pollution. However, I have never known a case of shallow well water that contained a clearly measurable amount of nitrites that did not appear to be contaminated.

Nitrogen as Free and Albuminoid Ammonia.—Nitrogen as ammonia, both "free" and albuminoid, frequently runs high in the Missouri River, the Missouri River bottom, in the upland, in shallow, deep and artesian wells. It is very variable and is not a safe index of pollution. In uncontaminated waters both factors may run from nothing to several tenths of a milligram a liter and only in extreme cases are these factors safe guides in deciding on the character of a water.

Oxygen Consuming Power.—This fact is also of doubtful value in very many cases. In uncontaminated waters it frequently runs up to several milligrams a liter, so that one must be on his guard in its use as a deciding factor.

In view of the difficulties encountered in the interpretation of sanitary water analyses in South Dakota, on account of the fact that some of the factors frequently run very high and are very variable, it would seem that it would be advisable to investigate the matter of the naturally occurring phosphates in order to learn whether this determination would not be of value in interpreting results.

PART TWO

The Determination and Significance of Phosphates in the Sanitary Analysis of Shallow Well Waters of Southeastern South Dakota*

Arthur L. Haines, Orville D. Dunbar and Alfred N. Cook

The determination of phosphates in the sanitary examination of water seems to have received comparatively little attention in this country. In the Journal of the American Chemical Society for February, 1901, Mr. A. G. Woodman, of the Massachusetts Institute of Technology, published an article on "The Determination of Phosphates in Potable Waters," and in the same journal for August, 1902, he published an article on "The Significance of Phosphates in Natural Waters." Mr. A. T. Lincoln, then of the University of Illinois, also published an article in the Journal of the American Chemical Society for August, 1904, entitled, "The Determination of Phosphates in Natural Waters." So far as we know these are the only articles published on this subject.

Because of the conversion of organic phosphorus compounds into phosphates through the process of decay it was thought that this determination might throw some light upon the pollution of shallow well waters in South Dakota.

Samples of water were collected in the localities of Mitchell, Beresford, Worthing, Dell Rapids, Colton, Ravinia, Alsen, Elk Point, Burbank, Meckling, Gayville, Vermillion, and the Missouri River bottom; also from the Missouri, the Vermillion, the Sioux and the James Rivers, and analyzed. With a few exceptions the samples were collected personally and the surroundings noted very carefully in regard to location, sanitary conditions about the well, and as to whether the slope was towards or away from any contaminated spots. In fact a very thorough survey of the surface conditions was made.

Each sample was collected in a container which had been thoroughly cleansed and then rinsed with the water

*The analyses were made by O. D. Dunbar under the immediate supervision of Professor A. L. Haines.

from which the sample was taken, after enough of the water had been discarded from the pump so that correct results might be obtained. The samples were collected from wells of various descriptions less than thirty feet in depth and from each of the rivers in the eastern part of the State. Eighty-five samples were analyzed in duplicate, in which were determined the chlorides, the required oxygen, the total solids, the loss on ignition, the phosphates, the nitrogen as nitrites, the nitrogen as nitrates, the free ammonia, and the albuminoid ammonia. These determinations, with the exception of the phosphates, were made according to the methods given by William P. Mason in his text on "Examination of Water." The phosphates were determined, as P_2O_5, according to the method used by W. G. Woodman in his work which was previously mentioned. It is as follows: "Take 50 c. c. of water. Add 3 c. c. of nitric acid. Evaporate to dryness on the water bath. Heat for two hours in the water oven. Extract with cold water. Dilute to 50 c. c. in comparison tube. Add 4 c. c. ammonium molybdate (50 grammes per litre) and 2 c. c. nitric acid. Mix, and after three minutes compare standards prepared by diluting standard phosphate solution (.1 mg. phosphorus pentoxide per c.c.) to 50 c. c. and adding reagents as above."

In the interpretation of the results not only the results of analysis were considered, but the surrounding conditions of the well. In a few instances, where it seemed impossible for the water to be contaminated and the results showed otherwise, we decided almost independently of the results of analysis. Also, in a few cases where the analysis showed little or no contamination and surroundings were very bad, we condemned the sample. Due to the difficulty in interpreting water analyses in South Dakota it is possible that we might have decided incorrectly in a few instances. For that reason, the condemned samples which contained less phosphates than the average of the samples classed as "good" and the samples classed as "good" which contained more phosphates than the average of the condemned samples were omitted in the averages in

an endeavor to establish a preliminary standard for phosphates.

The average for the phosphates in the eighty-five samples is 5.18 parts a million, while the average for the forty considered good is 3.74, the twelve considered questionable 5.94, and the thirty-three considered bad 6.26 parts a million. Taking out the five considered good which are above the average of the bad, and therefore exceptional, the average for the phosphates in the samples considered good is 2.65, or 2.53 parts a million below the general average for the phosphates. Also, taking out the eleven considered bad which are below the average of the samples considered good, the average for the phosphates in the samples considered bad is 7.82, or 2.64 parts a million above the general average. This gives a difference of 5.17 parts a million between the samples considered good and those considered bad, when the exceptional samples are omitted in both cases.

A difference in the phosphate content was also noted in the several localities. In and near Vermillion the average for all phosphates was 4.07, those considered good 2.22, and those considered bad 6.39. With exceptions omitted the good samples averaged 2.22, while the bad ones averaged 8.99, or a difference between the good and bad of 6.77 parts a million. At Burbank the general average was 5.89, the good samples 4.50, and the bad ones 6.10, or a difference of only 1.60 parts a million between the good and bad. The general average for the rivers was 6.43, the good ones 3.87, and the bad ones 5.00, or a difference between the good and bad of 1.13 parts a million. At Elk Point the average for all was 5.43, the good 4.44, and the bad ones 6.44. With the exceptions omitted the good samples averaged 4.05 and the bad ones 6.44, or a difference of 2.39 parts a million between the good and the bad.

All the samples from Mitchell were considered good, although some were very high in phosphates. The general average was 5.73, but with the exceptions omitted the average was reduced to 2.22 parts a million. The average for all samples collected on the Missouri River bottom was

6.43, for those considered good 5.67, and those considered bad 7.31. Omitting the exceptional samples, the good ones averaged 4.81 and the bad 8.00, giving a difference between the good and the bad of 3.19 parts a million of phosphate content.

The comparative results from the samples collected at Gayville were different from those of any other locality, as the phosphates were higher in the samples considered good than in those considered bad, the general average being 2.83, while those considered good averaged 2.91 and those considered bad 2.50. There were no exceptions among the good samples but all of those considered bad were exceptions, as they were below the general average of those considered good. It is possible that the low phosphate content might be due to the fact that nearly all of these samples were collected from driven wells.

It appears from the results obtained that the natural phosphate content of South Dakota shallow well waters is much higher than in any of the eastern States about which we have been able to gather data. The average of naturally occurring phosphates in the unpolluted waters of Massachusetts as determined by Woodman and given in the Journal of the American Chemical Society for August, 1902, was .67 parts a million, while in South Dakota the average for the unpolluted waters was 2.65 parts a million. The average of questionable waters in Massachusetts was 1.36 and in South Dakota 5.94 parts a million; while the average for those considered bad in Massachusetts was 2.39 parts a million of phosphate content and in South Dakota 7.82.

It would appear from the above results that a working standard for phosphates in southeastern South Dakota might be established which would be of occasional value in interpreting sanitary water analyses in that part of the State. However, due to the variation of phosphates in different localities, it would be necessary to establish a standard for each locality.

From the eighty-five analyses made it would appear

that if the phosphoric acid, figured as phosphorus pentoxide, be 7.80 or more parts a million it would indicate probable pollution, while if it is 2.65 or less the water is probably pure, and if between these two extremes it should be questioned.

PART THREE

Summary and Conclusions

Alfred N. Cook

1. Potable waters in South Dakota frequently contain 2,000 or more parts a million of mineral matter, in fact most waters run unusually high. The high mineral content cannot be regarded as an index of pollution, nor are such waters believed to be detrimental to health.

2. Loss on ignition usually runs very high and is rarely found to be of value in judging of the sanitary character of a South Dakota water.

3. Chlorides very frequently run from 100 to 300 parts a million and are very rarely of value in determining the sanitary character of a water.

4. Nitrates do not run abnormally high and consequently may be used as a reliable guide in judging the sanitary character of a water.

5. Nitrites, while they occur normally in deep wells in South Dakota, occasionally, never occur normally in shallow well water in any considerable quantity and the determination is of the usual value in the study of potable waters.

6. Nitrogen, both as free and albuminoid ammonia, is very variable and frequently runs very high in pure waters, so that these determinations are frequently of questionable value in deciding as to the sanitary character of a sample of water.

7. The oxygen consuming power was found to run very high in waters that were uncontaminated, in very many cases. This determination is therefore of less value in determining the quality of a water than in eastern localities.

8. Phosphates were determined in 85 samples, 40 of which were considered good, 12 questionable, and 33 bad. In the samples considered good the phosphates ran from 1.19 in a well in Vermillion to 14.00 in a well near Yankton, with an average of 3.74 milligrams for all of the 40 samples considered good. In the samples considered bad the average of 6.26 mgms. Leffmann states in his examination of water, page 120, "As regards phosphates Hehner states that the presence of more than 0.6 parts a million, calculated as P_2O_5, should be regarded with suspicion. Woodman, who has carefully investigated this question regards Hehner's limit as too strict. He would fix 1 part a million as the minimum." It will be observed that in not a single case was so small an amount of phosphates found in southeastern South Dakota waters as the upper limit set by these two men. Judged from their standard all of the eighty-five samples would be condemned and probably very few samples of water could be found in the eastern half of the State that would pass muster.

9. From the results of these eighty-five analyses I seriously doubt whether the determination of phosphates in eastern South Dakota would be of much value in water examinations, in view of the high and extremely variable content of naturally occurring phosphates.

10. This is intended to be only a brief preliminary investigation and it is hoped that the time is not far distant when a complete survey of the State may be attempted similar to that of Illinois and various other States. The State is mature enough and rich enough to make it highly profitable and the time would seem ripe for such an undertaking.

DATA FOR ALL SAMPLES

Sample	Chlorides	O. C. P.	Total Solids	Loss on Ignition	Phosphates	Nitrates	Nitrites	Free NH_3	Alb. NH_3	
1. Alsen—well near town; manure pile, 50 feet	71.39	5.60	2836	1287	4.30	3.505	.0040	.4406	.3884	Bad
2. Vermillion—barn, 100 ft. Cobb's well, level ground	117.41	3.38	2593	1171	3.61	.148	.0007	.0427	.2515	Bad
3. Vermillion—near old slaughter house	150.77	4.22	641	348	3.62	.174	.0004	.7500	.2950	Bad
4. Vermillion—Ortmeyer's well, clean locality	68.44	.20	1240	595	2.12	.029	Trace	.0661	.2969	Good
5. Vermillion—west part of town; clean locality	97.94	.66	2170	1387	2.28	.033	Trace	.0348	.5432	Good
6. Vermillion—N. E. part town; near residence, clean locality	46.66	.55	1180	515	1.86	.032	.0000	.0000	.2160	Good
7. Vermillion—N. W. part town; supposed to be alkali; conditions fair	19.47	3.50	4855	1478	1.43	.050	Trace	.0150	.4110	Good
8. Vermillion—Harrington's well; conditions fine	9.44	1.73	2685	901	1.37	.029	.0000	.0150	.0470	Good
9. Vermillion—Week's well; conditions very good	14.16	.45	650	315	1.43	.034	Trace	.0345	.1870	Good
10. Vermillion—on Cedar St.; location good; unused	116.23	.92	3187	362	2.00	.040	Trace	.0345	.1260	Good
11. Vermillion—5211 W. Cedar St., near chicken house; pond or slough, 100 ft.	102.07	3.48	1481	820	2.00	.036	.0003	.0200	.1104	Good
12. Vermillion—W. Cedar St.; location fine; slough, 150 ft.	9.44	2.38	543	254	1.66	.033	Trace	.0420	.0365	Good
13. Vermillion—Cherry St.; location fine	22.42	2.67	1122	465	1.65	.049	Trace	.0162	.1048	Good
14. Vermillion—Cherry St.; first house east of Waite's; location fine	19.86	2.39	887	466	1.87	.034	Trace	Trace	.0765	Good
15. Ravinia—well, 30 ft. deep	208.85	5.65	1548	113	1.45	.000	.0098	2.2270	.5390	Bad
16. Vermillion—Trusty's well; not well closed	120.93	2.99	1926	1127	1.19	.031	Trace	.0210	.0575	Good
17. Vermillion—Seaman's well; conditions very good	38.94	2.12	669	281	1.43	.031	.0000	Trace	.0670	Good
18. Vermillion—first well south of Seaman's, in back yard; chicken house 50 ft.	35.85	1.95	912	441	2.94	.033	.0000	Trace	.0355	Good

Sample	Chlorides	O. C. P.	Total Solids	Loss on Ignition	Phosphates	Nitrates	Nitrites	Free NH_3	Alb. NH_3	
19. Vermillion—Puckett's well; near barn, drainage good	138.15	3.17	2213	1102	2.21	.035	Trace	.0285	.0000	Good
20. Vermillion—Nels Weeks' well; unused, conditions bad	218.21	4.17	1834	1201	2.50	.031	.0011	.3950	.1200	Bad
21. Vermillion—just west Fair Grounds, E. gate; near pond	48.92	3.17	1716	711	3.43	.050	.0005	.1615	.0000	Questionable
22. Vermillion—just east Fair Grounds, E. gate; near pond	118.55	2.64	1664	922	4.82	.034	Trace	.2115	.0192	Good
23. Vermillion—Randolph's well; conditions very bad	256.65	4.85	7498	2805	5.52	.057	.0002	.3916	.0270	Bad
24. Vermillion—A. E. Burgand's well at edge of slough	85.53	6.27	1638	560	2.00	.050	Trace	2.1925	.0000	Bad
25. Vermillion—well in Fair Grounds; conditions poor	18.88	2.62	484	274	2.00	.065	Trace	.6468	.0000	Questionable
26. Vermillion—Wm. Groce's well; in back yard; conditions fair	101.25	6.43	1875	715	8.53	.100	.0000	2.1923	.0000	Bad
27. Vermillion—Geo. Weed's well; in back yard; conditions fair	21.24	1.87	1250	418	8.00	.077	.0000	2.5012	.2500	Bad
28. Vermillion—south of Grace's; in back yard; some garbage dumped there	127.44	3.40	1608	572	9.53	.111	.0000	1.2217	.5100	Bad
29. Vermillion—Milk's well; in back yard; conditions poor	72.57	2.89	1650	499	9.22	.125	.0000	1.4230	.4359	Bad
30. Vermillion—Schriner's well; cess pool, 50 ft.	36.58	7.88	1666	521	2.64	.125	.0000	.2154	.3231	Bad
31. Vermillion—well at depot; partly covered	212.40	2.39	3064	1000	3.18	.070	Trace	.1096	.1519	Questionable
32. Vermillion—well at store south of depot; conditions poor	205.91	2.25	3874	929	2.21	.080	.0003	1.3034	.0000	Bad
33. Vermillion—first house south of store near depot; conditions fair	181.41	2.92	2747	590	3.57	.200	.0000	1.8589	.0000	Bad
34. Vermillion—in yard, west end of town; conditions fine	95.58	1.77	3746	1015	2.95	.033	Trace	.4472	.0000	Good
35. Vermillion—50 ft. from sample 34; conditions fine	43.66	.55	2280	745	3.57	.033	Trace	.0500	.0788	Good
36. Burbank—west part of town; barn, 70 ft.; conditions poor; Sullivan's well	92.04	1.72	1607	422	6.22	.167	.0000	1.6285	.0560	Bad
37. Burbank—school well; filthy ditch near it	92.63	1.66	1564	411	6.40	.143	.0000	1.3077	.0000	Questionable
38. Burbank—in yard; barn, 50 ft.	184.67	2.72	1495	341	9.33	.095	.0015	.6250	.2083	Bad
39. Burbank—open well; bugs, etc., in it	337.48	3.42	2563	780	4.87	.505	.0014	.8353	.0646	Bad
40. Burbank—dug well, wooden cover and pump; barn, 50 ft.	462.56	3.92	1597	784	4.00	.580	.0032	.1077	.2163	Bad
41. Burbank—well by house; conditions fine	136.88	1.67	1696	466	4.50	.505	Trace	.2519	.0288	Good
42. Sioux River—above Dell Rapids	4.72	4.90	398	81	5.24	.143	Trace	.4140	.1813	Bad
43. Worthing—back of livery barn; drainage good	67.85	2.76	5255	1709	2.86	.047	.0008	.1038	.0615	Bad
44. Worthing—back of garage; drainage not very good	277.30	2.39	2177	1058	3.36	.040	.0001	.3794	.0208	Questionable
45. Beresford—just back of garage; open but well banked brick wall	186.44	2.40	2500	900	3.21	.050	Trace	.0884	.0543	Good
46. Beresford—well in back yard, 10 ft. from privy	220.66	3.79	4887	1813	11.05	.250	.0054	1.4890	.2795	Bad
47. Beresford—well in yard near kitchen door	307.98	3.88	4290	1525	16.80	.074	.0003	.0000	.1615	Questionable
48. Vermillion—east of Geo. Meade's; chicken house near	214.76	7.63	2195	699	9.13	.182	.0000	1.4078	.7114	Bad
49. Vermillion—first house west of blacksmith shop on river bottom; conditions fair	14.07	.86	1211	344	11.53	.200	.0000	.9932	.3106	Bad
50. Gayville—barber shop well; much filth near	322.14	2.46	2200	711	2.14	.111	.0036	2.5385	.0000	Bad
51. Gayville—Buchman's well; conditions fine	118.00	2.37	3964	481	1.86	.064	Trace	.0000	Trace	Good
52. Gayville—Ole Odland's well; near slough in pasture	70.80	1.42	992	396	2.93	.066	Trace	.0576	.0000	Good
53. Gayville—Nelson's driven well	101.48	4.28	1363	636	3.00	.125	Trace	.5000	.0882	Questionable

Sample	Chlorides	O. C. P.	Total Solids	Loss on Ignition	Phosphates	Nitrates	Nitrites	Free NH_3	Alb. NH_3	
54. Gayville—Ole Odland's; near residence	100.30	1.06	581	214	3.00	.118	Trace	.5263	.0678	Good
55. Gayville—Halverson's well; conditions fine	167.50	.51	1789	581	3.21	.071	Trace	.0000	.0000	Good
56. Gayville—Christenson's well; new, conditions fine	11.80	.95	657	233	3.57	.118	Trace	.5555	.0000	Good
57. Gayville—VanGorkam's well; conditions very good	34.22	1.30	722	240	2.86	.133	Trace	1.2500	.0000	Bad
58. Elk Point—Lyman's well; privy near	218.89	9.30	1522	750	5.89	.095	.0029	.0540	1.6243	Bad
59. Elk Point—Blair's well; near ditch along street	27.14	2.94	614	235	5.33	.057	.0001	.0692	.8122	Questionable
60. Elk Point—Thornton's well; conditions poor; dishwater emptied near	1096.90	5.66	5240	3054	7.00	.048	.0002	.0500	.3217	Bad
61. Elk Point—Moodie's well; conditions fair	249.57	4.05	1774	884	3.64	.050	Trace	.0000	.3333	Good
62. Elk Point—Dahlen's well; conditions fair	46.02	3.09	909	268	4.48	.066	Trace	.2000	.6461	Good
63. Elk Point—Goss's well; dishwater emptied in yard	710.95	5.51	3231	1506	5.09	.064	Trace	.0000	.1153	Good
64. Elk Point—Rozell's well; conditions fine	86.14	3.41	1379	461	6.40	.047	.0000	Trace	.4856	Good
65. Elk Point—Schaetzel's well; near residence	197.06	2.66	1806	1021	4.76	.050	Trace	.0000	.0000	Good
66. Elk Point—Walker's well; conditions fair	582.92	4.37	3474	752	2.29	.057	.0002	Trace	.3722	Good
67. Vermillion River; at boat landing, Vermillion	24.78	7.37	1363	339	5.60	.100	.0000	.0000	.4346	Good
68. Mitchell—Nix's well; near house; conditions fine	184.08	3.18	2007	991	9.15	.037	Trace	.0000	.2977	Good
69. Mitchell—Dr. Jenkins' well; conditions fine	125.67	2.22	3580	976	2.14	.333	Trace	.0000	.2000	Good
70. Mitchell—Broadbent's well; conditions fair	328.38	3.86	2401	1080	2.30	.714	Trace	.0000	.2918	Good
71. Mitchell—Dunbar's well; conditions fair	58.82	2.83	384	270	9.33	.303	Trace	.0346	.4253	Good
72. Elk Point—near town; Reid's well; conditions very good	172.28	5.87	1489	592	2.29	.030	Trace	Trace	Trace	Good
73. Northwest of Yankton—beside ravine	42.07	1.40	776	378	14.00	.038	.0002	.0000	.0577	Good

74. James River—near Yankton	120.95	12.05	1138	290	4.76	.067	.0000	.0346	1.0844	Bad
James River—near Huron	151.00	15.7	1504	299		.110	Trace	.045	.865	
75. Lake—northwest of Yankton; Lake Port, small lake in pasture	32.45	16.97	2520	688	10.67	.063	Trace	.6666	1.1619	Bad
76. Near Colton—old farm, Jostadt's well, stock tramped around it; in pasture near ravine	51.92	8.07	792	362	14.00	.035	.0005	.4307	.7270	Bad
77. Near Colton—new, Jostadt's (another farm); in pasture; stock near	7.08	2.27	498	212	9.74	.031	.0007	.0307	.3492	Bad
78. Vermillion—Farmers' well, foot of hill below town	151.04	2.74	2666	1064	10.66	.200	.0020	.0652	.0771	Bad
79. Vermillion—Grocham's well, foot of hill below town	167.67	6.16	3646	1052	11.20	.222	Trace	.0000	.1768	Questionable
80. Meckling—Schroeder's well; in yard; conditions good	110.28	1.70	1530	460	9.74	.023	Trace	.9080	.2261	Questionable
81. Meckling—Overton's well; conditions fair	88.50	1.95	1336	954	2.86	.028	Trace	.6056	.2010	Questionable
82. Meckling—school house well, conditions poor	118.59	1.25	1426	354	10.96	.032	Trace	.8332	.3009	Bad
83. Meckling—in back yard	11.80	1.67	1098	304	10.18	.031	Trace	.8332	.0000	Good
84. Missouri River—at ferry, 11 miles west of Vermillion	11.08	3.41	266	94	2.14	.074	.0000	.0000	.0000	Good
85. The Ferry—well 100 ft. from Missouri River bank; barn 60 ft.	29.50	2.85	980	288	4.00	.054	Trace	.8332	.5954	Questionable
AVERAGE	139.64	3.77	1999	748	5.18	.115	.0005	.4684	.2298	

TABLE OF AVERAGES

	Chlorides	O. C. P.	Total Solids	Loss on Ignition	Phosphates	Nitrates	Nitrites	Free NH_3	Alb. NH_3
For all samples	139.64	3.77	1999	748	5.18	.115	.0005	.4684	.2298
For good samples	118.58	2.50	1708	709	3.74	.049	.0000	.0896	.1556
For questionable samples	124.59	3.00	1897	717	5.94	.071	.0001	.4659	.2028
For bad samples	169.69	4.71	2188	810	6.26	.200	.0012	.9188	.3294
For samples from Vermillion	103.26	2.17	1934	796	4.07	.077	.0002	.5110	.0166
For samples from Burbank	217.71	2.35	1769	534	5.89	.094	.0010	.7927	.0957
For samples from rivers	65.38	3.25	1907	749	6.43	.132	.0003	.7639	.3096
For samples from Elk Point	357.42	4.56	2218	993	5.43	.059	.0004	.0415	.5234
For samples from Mitchell	174.23	3.02	2093	829	5.73	.347	Trace	.0086	.3037
For samples from river bottom	176.98	3.25	1907	749	6.43	.132	.0003	.7639	.3096
For samples from Gayville	115.78	1.79	1534	436	2.83	.101	.0005	.6784	.0195