Journal of the Minnesota Academy of Science

Volume 3 | Number 3 Article 10

1890

Artesian Wells in North and South Dakota

Warren Upham

ARTESIAN WELLS IN NORTH AND SOUTH DAKOTA.—

By Warren Upham.

On the broad fertile plain called the Red river valley, which was the bed of the glacial lake Agassiz, many artesian wells have been obtained within the thick drift sheet, deriving their supply of water from porous beds or veins of sand and gravel beneath and frequently between deposits of bowlder clay or till. The depths of these wells vary from 40 to about 250 feet, and the height to which the water is capable of rising is often only a few feet and seldom more than 25 to 50 feet. Hundreds of these flowing wells, commonly one to two inches in diameter of pipe, are in use on farms, at grain elevators, and for the supply of towns, on both the Minnesota and North Dakota sides of the Red river. Some tracts of considerable area, however, fail to find artesian water, but even these generally encounter water-bearing layers at depths corresponding with those of the artesian wells, from which water rises nearly to the surface.

The narrow areas that may be sometimes occupied by the sand and gravel layers yielding artesian water, or the thin and in some places entirely deficient condition of these layers, is illustrated by the different depths at which a flow of water was first encountered by four wells in the village of Grandin, North Dakota. These wells are on an area only about 50 rods in extent, and their several depths are 105 feet, 158 feet, 187 feet, and 248 feet. Either the upper water-bearing beds here are narrow, like a stream course, so that they were not found by the deeper wells, or, if they exist as sheets of great width as well as length, they are in some parts thinned out, allowing the impervious till above to rest on that below. But in the direction from which the water supply is received, these gravel and sand veins or beds must have a great extent and descend from levels higher than the surface of the central part of the Red river valley, where the artesian wells are situated. At least this must be the case where the water is fresh or only very slightly saline, as at Grandin and in all the southern part of the valley as far northward as to the vicinity of Crookston in Minnesota, and Blanchard in North Dakota, and in a large district of Manitoba including Winnipeg and the Mennonite reserve east of the Red river.

North of Crookston and Blanchard to the international boundary, and in the south edge of Manitoba, the water of these

wells, almost without exception, is distinctly saline and alkaline. It seems very probable that the water-bearing beds of that large portion of the Red river valley differ widely in the origin of their water supply from the foregoing. Instead of deriving their water, like the fresh artesian wells, from the rainfall upon higher parts of the drift surface contiguous to the Red river valley, there seems to be good reason for believing that the brackish water is mainly from the basal sandstone of the Cretaceous series, coming through that sandstone from its outcrops on the flanks of the Rocky mountains and Black hills, and permeating upward into the drift of the Red river valley from areas where this sandstone is the underlying bed-rock.

Deep artesian wells of somewhat saline and alkaline water, like that of the part of the Red river valley just described, are obtained on a belt that extends across North and South Dakota from Devil's lake to Yankton and Vermillion, including the greater part of the James river basin. Wherever borings along this belt have penetrated to the Dakota sandstone, the lowest formation of the Cretaceous series in the upper Missouri region, artesian water has been found. Probably as many as a hundred wells have been bored, their depths ranging from 900 to 1,550 feet, except in the southern part of the James and Vermillion valleys, where many wells are only 600 to 750 feet deep, and a few, the farthest southeast, are between 300 and 400 feet in depth. These wells are mostly five or six inches in diameter, and their strong pressure, commonly from 50 to 175 pounds per square inch at the surface, makes them valuable not only for fire-hydrants, but also to furnish power for manufacturing purposes. Several wells have been bored at Aberdeen, and three years ago, in 1887, fifteen wells were in use in Yankton. The pressure of the wells in Yankton is sufficient to raise the water 129 feet, and in numerous places along the middle portion of the James river valley, as Huron, Redfield and Aberdeen, the pressure corresponds to a rise of more than 400 feet above the surface.

The sections of these deep wells in North Dakota and on the high land between the James and Missouri rivers in South Dakota, include, beneath the drift, the Fort Pierre, Niobrara, and Fort Benton divisions of the Cretaceous series; but along the lower part of the James river and on the Vermillion erosion during the Tertiary era removed the upper portion of these beds,

leaving only the Fort Benton shales or a part of that formation over the Dakota sandstone.

At Devil's lake, where an artesian well was bored last year, about six feet above the depot, or 1,470 feet above the sea, the section was as follows:

Section of well at Devil's Lake.

Glacial drift, till as on the surface	25 feet.
Dark shale, nearly alike through its whole thickness, including the Fort Pierre and Fort Benton formations, with no noticeable calcareous beds at the intermediate Niobrara horizon	1,403 feet.
Gravel, of granitic pebbles up to a half inch in diameter, firmly cemented with nodular pyrite	3 feet.
Dakota sandstone, or rather a bed of lose sand, very fine, white or light gray, the base of which was not reached	80 feet.
Total	1,511 feet.

From the sandstone, at the depth of 1,470 feet, artesian water came up with a rush, but sand soon filled the pipe so that the supply became small. It is from this level that the present flow comes, through narrow slits cut in the pipe. The boring was continued forty feet deeper, but no such strong flow was obtained below. In July, 1889, when the well was completed, it supplied 1,800 barrels of water in 24 hours, or about 40 gallons per minute, the diameter of the pipe being 8 inches, reduced to 3½ inches in the lower portion. The stream flowing away was then turbid with the exceedingly fine particles of sand brought up from the bottom.

The Jamestown well, bored in the winter of 1886-7, about eight feet below the depot, or 1,400 above the sea, went through a similar section of about 1,400 feet of shales, with no distinctly different portion to indicate the place of the Niobrara formation. The same nearly uniform section has also been found to a depth of 1,350 feet at Deloraine in Manitoba, close northwest of the Turtle mountain, as I am informed by Mr. J. B. Tyrrell, of the Geological Survey of Canada. At that depth, which was bored last year, there still lacked about 300 feet of reaching the sea level, from which the Devil's lake artesian water rises.

For the greater part of my notes of the artesian wells of South Dakota, also of Ellendale and Oakes, in North Dakota, I am indebted to *Resources of Dakota*, published by the territorial Commissioner of Immigration in 1887, and to recent correspond-

ence with Prof. G. E. Culver, of the University of South Dakota, and with Prof. C. W. Hall, of the University of Minnesota. These data, with those obtained by me at Devil's lake and Jamestown, I have placed in tabular form for convenient comparison, showing (1 and 2) the distances of the localities north and west from the mouth of the Big Sioux river at the southeast corner of South Dakota; (3) depths of the wells; (4) their pressure at the surface, wherever it has been obtainable, in pounds per square inch; (5) the corresponding height or head to which the water would rise above the surface; (6) the altitude, with reference to the sea level, of the source of the artesian water in the Dakota sandstone; (7) the altitude of the surface; and (8) the height of the computed head of water above the sea.

Artesian wells deriving water from the Dakota sandstone in North and South Dakota.

Locality.	Distances in miles on latitude and longitude from the Southeast corner of South Dakota.		Depth in feet.	Pressure at surface in pounds per sq. inch.	Head in feet above surface computed from pressure.	Altitudes in feet above the sea.		
	North.	West.				Source of water in upper part of Dakota sandstone.	Surface, railroad at station.	Head computed from pressure.
Devil's Lake	390	119	1511			0	1464	
Jamestown	305	110	1476	95	219	−76	1408	1619
Oakes	252	80	944			378	1322	
Ellendale	243	101	1087	125	288	362	1449	1737
Britton	228	72	1004			350	1354	
Columbia	216	92	965	175	404	339	1304	1708
Andover	202	72	1070	90	208	406	1476	1684
Groton	204	82	960	187*	432	344	1304	1734
Aberdeen	206	101	908	175	404	392	1300	1704
Ipswich	204	127	1270	70	162	200	1530	1692
Mellette	186	101	900			400	1300	
Ashton	174	101	915	50*	115	381	1296	1411
Doland	167	81	950			405	1355	
Redfield	166	103	900	175	404	395	1295	1699
Faulkton	176	132	1210			363	1573	
Hitchcock	148	97	950	175	404	389	1339	1748
Huron	130	88	863	175	404	424	1287	1691
Miller	140	126	1148	125	283	439	1587	1875
Highmore	141	148	1552	25	58	338	1890	1948
Harold	141	163	1453			348	1801	
Woonsocket	108	91	750	153	353	558	1308	1661
Letcher	97	85	600			700	1300	
Mitchell	84	79	600			701	1301	
Plankinton	85	102	760			778	1523	
Kimball	87	126	1068			720	1788	
Vermillion	20	24	365	15	35	785	1150	1185
Meckling	23	31	338			818	1156	
Yankton	27	46	610	56	129	586	1196	1325
Tyndall	34	71	730			688	1418	
Ft Randall	38	106	600	4	104	660	1260†	1364

*The pressure reported at Ashton is 100 or 125 pounds less than would be expected in proportion with other localities; and at Groton it is somewhat more. The discrepancy of the latter, however, is no greater than may be due to superior permeability of the water-bearing stratum.

†Approximate altitude of high water of the Missouri river at Fort Randall.

The flow of water from the Dakota sandstone at Devil's lake is found exactly at the sea level, but the top of the sandstone formation is 39 feet higher. At Jamestown the flow rises from a depth of 76 feet below the sea level, indicating that the top of the Dakota sandstone there sinks slightly lower than at Devil's lake. Along the distance of eighty-five miles from north to south between these points, its level is probably nearly constant; and boring at intervening towns, as New Rockford and Carrington, will doubtless find artesian water at or slightly below the sea level. Farther south, the top of the sandstone and its water supply are found throughout a large district of South Dakota and the south edge of North Dakota, at a plane 250 to 450 feet above the sea. Continuing still southward, from Woonsocket to the Missouri river, the water-bearing stratum rises to altitudes from 558 feet to 818 feet above the sea, the highest levels being at Meckling and Vermillion, the most southeastern localities of this list.

The same southeastward ascent of the Dakota sandstone reaches to its outcrops on the southwest side of the Missouri in Dakota county, Nebraska, whence its name is derived, opposite to the southeast corner of South Dakota. There and at other extensive outcrops in western Iowa and eastern Nebraska, having approximately the same elevations as the surface at Vermillion and Yankton, the water coursing through this sandstone finds outlet in springs; and these avenues of discharge explain the gradual reduction of the altitude of the head of the water above the sea level, as the series of wells is followed from north to south and from west to east. Somewhat uniform altitudes of 1,619 to 1,743 feet are recorded as the heights to which water would rise in pipes for all the wells, where pressure is reported, from Jamestown to Huron and Woonsocket, excepting those west of Huron, which will be considered later, and the well at Ashton, where the reported pressure is probably erroneous, lacking 100 pounds or more of its true amount. At Hitchcock the head of water has a computed altitude of 1,743 feet above the sea; eighteen miles to the south, at Huron, it is 1,691 feet; twenty-two miles further south, at Woonsocket, it is 1,661 feet; and eighty miles still farther south, at Yankton, it is only 1,325 feet.

Equally distinct gradients of the plane of water head are found descending from west to east on and near the latitudes of Huron and Yankton. Thus at Highmore, sixty miles west of

Huron, the head is 1,948 feet above the sea; at Miller it has declined 73 feet in a distance of twenty-two miles to the east; and in the thirty-eight miles thence to Huron it falls 184 feet more. Between Fort Randall and Yankton, in a distance of sixty miles from west to east, this plane descends at least forty feet, but the descent is more if the well at Fort Randall is at a considerable height above the Missouri river. In the next twenty-two miles eastward to Vermillion the descent is 140 feet. This feature of the artesian water supply is caused, as before stated, by its outlets through springs in outcrops of the Dakota sandstone, which begin thirty to forty miles southeast of Vermillion and extend thence southeast and south.

All of the eastern outcrops of the Dakota sandstone are lower than the upper portion of the James river basin and the wells farther west at Highmore and Harold. These outcrops therefore cannot be the sources from which the sandstone receives its artesian water, but, as we have seen, they are the avenues of its natural outflow. We must look instead to the western outcrops of this formation, where it skirts the Black Hills and exposes its upturned edges along the base of the Rocky mountain ranges, for the area upon which water is carried downward into the sandstone. Thence we know this stratum to be continuous beneath the plains to the James river valley, for there are no nearer nor other inlets from which the copious supply of the artesian wells can come. At a plane of greater or similar depth an artesian reservoir exists beneath much, if not all, of the country westward to the mountains. The gradients of the altitudes to which the water of wells is capable of rising along east to west lines in South Dakota, as at Huron, Miller, and at Highmore, are approximately the same as the average westward ascent of the country, demonstrating this western origin of the water supply, and indicating that such wells may be obtained upon an extensive region of the arid plains.

How far then can this artesian water be utilized for irrigation? Will it then be practicable to store the water in reservoirs for use in the season of growing crops, and especially during severe droughts, like that which so reduced or in some portions entirely cut off the crops in North and South Dakota last year? To this inquiry we may reply by computing the amount of water needed for irrigating a given space, as a quarter section of 160

acres, the usual area of a homestead. Allowing a depth of twelve inches of water for this use during the growing season, the year's supply of water from a well flowing 100 gallons per minute is required, without allowance being made for leakage or evaporation from the reservoir. The Devil's lake well would therefore irrigate only 64 acres, and the Jamestown well, flowing 375 gallons per minute will water less than a section one mile square. But each of these wells cost about $7,000, to which must be added the cost of the construction of reservoirs and irrigating ditches, placing the expense of such water supply far beyond its prospective value for ordinary agriculture.

An important objection, however, against the use of this water for irrigation seems to lie in its dissolved alkaline and saline matter, which must be left in the soil. After continued use in irrigation during many years the residuum from this water would quite certainly prove injurious to crops, so that the land would become worthless. Such results have attended irrigation with only very slightly alkaline water on the alluvial plains of the arid northwestern provinces of India. The proportion of sulphate of soda in streams flowing down from the Himalayan range and in canals taking water from them varies from 9 to 43 parts in a million, and the proportion of common salt is from 0.23 to 15 parts; yet under the dry climate of northwestern India the natural evaporation of so nearly pure water, and its use in irrigation have caused extensive tracts of land formerly productive to become barren.*

The analysis of the water of the Jamestown well, which, doubtless closely resembles that of all the wells obtaining their supply from the Dakota sandstone, is given by Prof. James A. Dodge, as follows:

Analysis of the mineral matter in the water of the artesian well at Jamestown, North Dakota.

	Parts per Million.	Grains per Gallon.
Silica	35.7	2 0823
Alumina	3 5	.2041
Carbonate of iron	2.2	.1283
Carbonate of lime	188 0	10.6743
Sulphate of lime	249 0	14.5241
Sulphate of magnesia	154.2	8.9944
Sulphate of soda	1139.4	66.3602
Sulphate of potash	81.5	4 7523
Chloride of sodium	369.1	21.5296
Phosphates	Traces.	.....

* Medlicott and Blanford, Manual of the Geology of India, pp. 413-415.

The quantities of alkaline matter and salt are sufficient to give the water a brackish taste, rendering it unpalatable for drinking and unfit for ordinary domestic uses; but it is drank freely by cattle and horses, with no unfavorable effects. These dissolved mineral ingredients seem to have been derived from the Cretaceous shales, and probably in part from beds in the Dakota formation, with which the water has been in contact during its slow percolation hundreds of miles through the sandstone. They are the same in kind and similar in amount with the mineral matter of Devil's lake, concentrated by evaporation without outlet from the water of inflowing streams and springs, which bring very small amounts of these salts dissolved from the drift and Cretaceous shale of the adjoining country.

Much shale, gravel and detritus, rich in sulphates, are present in the glacial drift over nearly the entire Red river basin, and the percolating rain-water, found by the fresh artesian wells in the drift of the southern and northern ends of the Red river valley, has acquired minute quantities of alkaline and saline matter. But where its proportion is large, as in the brackish water of the wells from Crookston and Blanchard northward to the edge of Manitoba, it seems impossible that so remarkable a difference can be due to diversity in the material of the drift, or to longer time and better opportunity afforded to the water for such impregnation while percolating through porous beds or veins in the drift. The saline and alkaline artesian waters of the drift, gravel and sand along this central portion of the Red river valley therefore appear to be received mainly from the same Dakota sandstone which supplies the deep wells of the James river valley.

Several wells in the vicinity of Blanchard and Mayville, 375 to 404 feet in depth, pass through the drift and enter a very fine white sandstone, probably the Dakota formation, from which they obtain flows of brackish water. About a dozen miles east of Blanchard the drift was found to have a total thickness of 310 feet below which a boring went 107 feet into exceedingly fine white sandstone, finding, however, no artesian water, apparently because of the very close texture of the rock. The top of the sandstone in these wells is 650 to 575 feet above the sea. If it is the Dakota sandstone, as seems probable, it has an ascent of about 600 feet in 75 miles east from the meridian of Devil's lake and Jamestown, rising in its approach toward the Silurian, Cam-

brian and Archæan areas of Minnesota and Manitoba. It may be thus the bed-rock, on which the drift is deposited, beneath extensive tracts in the middle part and on the western border of the Red river valley, discharging there its alkaline and saline artesian water into the permeable beds of gravel and sand in the drift sheet, whence it rises in the brackish wells of that district.

Besides the classes or groups of artesian wells thus far considered, there remain to be mentioned numerous shallow flowing wells, from 20 to 168 feet deep, in the drift of the Vermillion river basin in South Dakota, reported by Prof. G. E. Culver, and two deep artesian wells in North Dakota at Tower City and Grafton. The wells in the vicinity of the Vermillion river are on an area unmarked by grand contrasts of elevation, though toward the north and northeast the surface gradually rises in the Coteau des Prairies. They seem to be comparable with the plentiful flowing wells or fountains along the Maple river in Blue Earth and Faribault counties, Minnesota.

The Tower City well, fifty miles east of Jamestown, is four feet lower than the depot, being 1,168 feet above the sea. Its depth is 670 feet, through drift, 163 feet; Cretaceous shales, with occasional beds of sandstone, 502 feet; and quicksand, into which the boring advanced only 5 feet. Salty and alkaline water outflows 9½ gallons per minute, and is capable of rising 33 feet above the surface. The scanty flow and low head of this well suggest that the water-bearing stratum may be enclosed within the Fort Benton shales; but its altitude, 500 feet above the sea level, accords with that of the sandstone reached by wells at Blanchard and Mayville, so that more probably it is the top of the Dakota formation. The plane of the head of water supplied from this formation would show a marked descent northeastward, as is thus indicated at Tower City and in less degree at Devil's Lake, in comparison with Jamestown and Ellendale, if there are abundant natural outlets of this artesian water along the Red river valley, as appears to be true, by springs rising through the drift. These brackish springs occur on many of the streams tributary to the Red river both in North Dakota and Minnesota, the most remarkable being on Forest and Park Rivers, which therefore were formerly called the Big and Little Salt rivers.

At Grafton, in the Red river valley on the Park river, the artesian well, 825 feet above the sea, is 915 feet deep, going

through (1) drift, 298 feet; (2) limestone, apparently the Lower Magnesian formation of the Cambrian series in southern Minnesota, 137 feet; (3) white sandstone, referred to the Jordan formation of the same series, 65 feet, yielding a copious flow of brackish water; (4) reddish, blue, and gray shales, with some arenaceous or cherty and dolomitic beds, representing the Saint Lawrence formation of that series, 398 feet yielding a feeble flow of very salt water from its upper part; (5) sandstone, perhaps a trace of the Dresbach sandstone of southeastern Minnesota 5 feet, yielding a small flow of brine, which was analyzed by Prof. Henry Montgomery, of the University of North Dakota, and pronounced more saline than sea water; and (6) granite, as determined by Prof. N. S. Shaler from specimens of the borings, 12 feet. The water used from this well is taken from the top of the Jordan sandstone, at the depth of 438 feet. The diameter of the pipe is six inches, and the flow, according to three measurements in 1886 and 1887, during the first year after the completion of the well, was 800 gallons per minute. The reference of this section to the Cambrian series seems to be well determined by correlation with other wells penetrating Cambrian strata in this valley at Humboldt, Minnesota, and Rosenfeld, Manitoba, respectively about thirty-five and fifty-five miles farther north. At Rosenfeld, however, according to my interpretation of the section, the Cambrian series is overlain by 352 feet of Lower Silurian strata, which there are the bed-rocks first encountered below the drift. Not far west of Rosenfeld and south of Grafton, the Dakota sandstone, forming the base of the great Cretaceous series which is penetrated by the wells at Deloraine, Devil's Lake and Jamestown probably abuts, with horizontal or only slightly inclined stratification, upon the similarly almost horizontally bedded Silurian and Cambrian rocks.

June 10, 1890.