

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Conservation and Survey Division

Natural Resources, School of

10-1930

Lincoln's Water Supply Problem

Follow this and additional works at: <https://digitalcommons.unl.edu/conservationsurvey>

 Part of the [Geology Commons](#), [Geomorphology Commons](#), [Hydrology Commons](#), [Paleontology Commons](#), [Sedimentology Commons](#), [Soil Science Commons](#), and the [Stratigraphy Commons](#)

"Lincoln's Water Supply Problem" (1930). *Conservation and Survey Division*. 373.
<https://digitalcommons.unl.edu/conservationsurvey/373>

This Article is brought to you for free and open access by the Natural Resources, School of at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Conservation and Survey Division by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

LINCOLN'S WATER SUPPLY PROBLEM

BULLETIN 4
CONSERVATION DEPARTMENT
of the
CONSERVATION AND SURVEY DIVISION
UNIVERSITY OF NEBRASKA



LOAN COPY

Conservation & Survey Division
113 Nebraska Hall
The University of Nebraska - Lincoln

By Authority of the State of Nebraska
Lincoln, Nebraska
October 21, 1930

LINCOLN'S WATER SUPPLY PROBLEM

BULLETIN 4
CONSERVATION DEPARTMENT
of the
CONSERVATION AND SURVEY DIVISION
UNIVERSITY OF NEBRASKA



By Authority of the State of Nebraska
Lincoln, Nebraska
October 21, 1930

THE UNIVERSITY OF NEBRASKA
EDGAR A. BURNETT, Chancellor

CONSERVATION AND SURVEY DIVISION
G. E. CONDRA, Dean and Director

BOARD OF REGENTS

HON. JOHN ROBINSON WEBSTER, Omaha
HON. FRANK TAYLOR, St. Paul
HON. EARL CLINE, Lincoln
HON. STANLEY D. LONG, Cowles
HON. MARION A. SHAW, David City
HON. FRED A. MARSH, Archer

LINCOLN'S WATER SUPPLY PROBLEM

BY G. E. CONDRA

Some claim that Lincoln has no water problem; others view the situation with alarm. However, all agree that a dependable water supply of good quality is one of the most important factors in the life and growth of any municipality and especially so of Lincoln, the Capital and State Institution City of Nebraska.

The substance of the statement following is based on field study made in connection with the State Geological Survey and the State Water Survey. It includes data which have been discussed before the City Planning Committee of the Lincoln Chamber of Commerce, the State Well Drillers Association and the State Irrigation Association. It presents geological and water resource data with some variance from concepts formerly held and described. The engineering features of the water supply are not covered because others are better qualified to handle that phase of the problem.

SOURCE OF WATER SUPPLY.—Lincoln's water supply is pumped largely from ground water in the well-known Dakota formation. The wells range from 80 to about 205 feet in depth and are quite widely scattered. The heaviest pumping is in Antelope valley.

The geology of the water storage ground and the process of water accumulation therein at Lincoln have a place in the water problem. These conditions have been explained at times, but more on a basis of supposition than on a basis of survey and facts. This has resulted in some error regarding the source and permanence of the water supply.

Although it has been claimed by some that practically all of the well water supply of Lincoln reaches the area by long distance underflow in the Dakota from intake along the Rocky Mountain front and other points west and northwest, it is now believed that most of it is from local rainfall and local drainage. The reasons for this conclusion are given elsewhere in this paper.

DAKOTA FORMATION.—This formation underlies all or nearly all of the city. It is exposed at one point in Antelope Park, at Robbers Caves, near the Penitentiary and at many other places at and near Lincoln. It extends far out in all directions from the city, especially to the west and northwest. The upper beds of the Dakota have been removed by erosion near Lincoln and all of it has been eroded through and away at Roca and Bennett. The formation underlies probably all of central and western Nebraska and the adjacent states out to the Rocky Mountains and Black Hills and reaches northeastward to beyond Sioux City. Generally in this distribution, the upper zone of the formation or group is known as the Dakota sandstone; the irregular middle zone as the Fuson shale, and the lower zone as the Lakota sandstone.

The Dakota group of beds consists principally of sand, sandstone and clay shale. Much of it is water-bearing but in the vicinity of Lincoln most of the water has been drained out of the remnants of the upper zone (Dakota proper); some water occurs in sandy portions of the middle zone (Fuson) and a large amount occurs in the lower zone (Lakota) from which much of the City supply is drawn.

DAKOTA STORAGE WATER.—There is a rather sharp line at Lincoln between the storage water area with good water and the saline areas which seems to be replenished by underflow from the west and by leakage from formations deeper and older than the Dakota. Herein is a condition not fully understood. Thus far we have not been able to determine beyond some doubt why there should be such a break between the area of good water storage and the saline areas. Apparently, the explanation is about as follows: Formerly the Dakota extended as a continuous formation across the Salt Creek area to Iowa. Then, when Salt Creek valley was eroded in, and at places through the Dakota to the Pennsylvanian beds, the area east of the valley was nearly cut off from the main area west of the valley. This diverted the underflow of the formation to Salt creek and thence to the Platte and facilitated the outward drainage of the mineralized water in the outlier east of Salt creek. All told it became impossible, on account of the discontinuity of the Dakota beds, for the Dakota underflow from the west to move into the areas from which the City supply is now drawn. Then, too, salt water of the Pennsylvanian beds escaped to the bottom ground of the deep valley, which leakage and movement may have been caused in part by bed rock deformations.

Following the episode of deep erosion, the valley was filled with alluvial materials to the height of the terraces and then eroded to the level of the present bottomlands or lower. During the time of valley deposition and later to the present the Dakota water from the west and the salt leakage from below have concentrated mineralized water in the alluvial ground and drained northeastward down Salt creek.

The Dakota area east of Salt creek, being more or less disconnected from the main distribution of the formation west does not now receive much of the mineralized water from the west except by invasion through the alluvial ground along its border. It is replenished more from local rainfall and local drainage. Also, there are certain well-defined geologic and topographic conditions which facilitate the intake of local run-off and underflow into the disconnected Dakota area.

A further point in this discussion is that the Dakota water west of Salt creek valley, as shown by analysis from many wells, differs in chemical composition from that in the area east. It is more mineralized and becomes even more saline in the bottomland. It certainly would not come on through less mineralized on the east where the city wells are located. So it should be apparent that the old notion that the Lincoln water supply comes by a long journey underground from the Rocky Mountains, in never failing volume protected against pollution, is not well founded.

Saline water areas occur in the Dakota at points north and west of the city, and at places yet farther out, except where, like under much of Lincoln, there is local intake from the rainfall and run-off due to topographic and structural conditions. One of the largest areas of less mineralized water in the Dakota is in the northeastern counties of Nebraska where much water enters the formation along its outcrop area, from the northeast, and does not reach its storage position by a long journey underground from the mountains to the west as some have supposed.

Surface water enters the Dakota beds along Salt creek in the vicinity of Roca where the uneven base of the formation lies on the Pennsylvanian limestones and shales which rise above the valley floor. From this point to past Bennett the unconformable contact between the Dakota and Pennsylvanian drops northwestward and westward under Lincoln. The contact is very uneven with some Pennsylvanian highs reaching to near the surface and not covered by the Dakota beds. There is no water of importance on these hills or highs of the Pennsylvanian, the underdrainage being in and through the Dakota-filled valleys leading towards Lincoln. Surface water entering the mantle rock and the Dakota in this catchment becomes the source of much of the water supply of the city.

SALT INVASION.—Although much of the Dakota water at or near Lincoln is not too heavily mineralized for drinking purposes, there are places where it is quite saline. Most of Lincoln and vicinity east of Salt creek is underlain at shallow depth by good water, but much of the area just west of this is more saline. Heavy pumping and the consequent draw down along the west border of the good water zone, i.e., close to the saline areas, results in salt water invasion eastward to the storage areas from which the present supply of the city is drawn.

The problem of salt water invasion can be met to some extent by drawing relatively more water from the areas farthest removed from the salt zone and thus limiting the draw down near the saline areas. The problem involves the conservation of ground storage capacity as well as the conservation of water. Fortunately, the city has considerable ground storage area east of Salt creek. This earthen storage reservoir should be protected.

SEARCH FOR WATER.—Apparently the ground water of the pump areas of the city is being exhausted faster than it is replenished by nature. This very unfavorable situation should be recognized by the city. The Water Department of the city has prospected the water resources in and for some distance out from Lincoln quite closely, and gradually expanded the water supply area. Much of the promising ground has been covered and the maximum permanent capacity to produce water seems to have been about reached. Further points should not be overlooked. First, all of the ground water storage area at Lincoln is underlain by salt water at a comparatively shallow depth. Second, it is not good economic procedure to expand the well and pipe line connections widely over an area of limited water supply. All told, the conditions evidence a strong need for the location of a supplemental water supply. Investigation for this expansion is now under way by the city.

DANGEROUS SITUATION.—Fortunately, most of the physical factors relating to Lincoln's water supply are favorable so far as healthfulness is concerned, but there are at least two conditions which might cause trouble. First, most of the ground water comes from local rainfall and surface drainage in much of the Lincoln basin, making it subject to pollution at places. Second, the Dakota formation which affords the storage is very irregularly bedded, cross-bedded and broken somewhat by deformations. This means that there are places where the surface water enters the ground water and the water system more readily than some have supposed. The conditions just cited mean that

the water is not safe for drinking purpose without the treatment made by the Water Department.

AVAILABLE WATER.—There are sources from which to produce additional water for the city, as follows:

1. Undeveloped areas in the Dakota formation.
2. St. Peter sandstone.
3. Terraces and flood plains of Salt creek valley.
4. Drift hills.
5. Branches of Salt creek.
6. Big Blue river.
7. Loess plain area.
8. Todd valley.
9. The Platte river and the Platte valley.

1. UNDEVELOPED DAKOTA SANDS.—Just how much additional water might be developed from the Dakota beds in the vicinity of Lincoln is not definitely known. However, it is evident that by expanding the water system in Antelope valley, between the Penitentiary and College View and yet farther southeast and northeast, some additional supply could be had, but to draw upon this would intercept some underflow to the storage now drawn upon. It would require heavy expense for the many well and pipe line connections and not add water in proportion to the area covered. Also, as already stated, there are no possible areas of Dakota water in other directions (nearly all being saline) except the small storages now utilized on farms and at two of the state institutions. So as a whole the Lincoln area is not at all promising as a source of new water from the Dakota beds.

2. ST. PETER SANDSTONE.—Most of the geological formations below the Dakota carry mineralized water. In one horizon, i.e., what is supposed to be the St. Peter sandstone, the water is suitable for city purposes. This supply, at a depth of about 2,000 feet, would, if developed, require heavy expense for drilling and for casing-off the salt water above. We need not expect, therefore, because of its depth, the cost of wells and the comparatively limited supply, to draw supplemental water from the so-called St. Peter sandstone.

3. TERRACES AND FLOOD PLAINS.—The various valleys of Salt creek in the vicinity of Lincoln are occupied by well-defined terraces (second bottoms) and broad flood plains (first bottoms). The terraces and in places the flood plains are underlain with considerable sand and gravel with large amounts of water. However, unfortunately, much of this water is saline. Only in those places where the ground water storage is built up by run-off from non-saline land and there is little or no leakage from the deeper sources to these local storage areas, is the water suitable for city purposes.

One of the main areas of favorable bottom ground storage occurs along Salt creek west and southwest of the Penitentiary on the Branson place and in lands farther south in the valley. This water is derived from local rainfall and from the stream which comes down from Sprague, Hickman and Roca. There are two geological sources of the water at this location, i.e., the alluvial sands and the Dakota, the first named of these being the more important, because the Dakota storage here is not far from the salt areas and probably would become invaded by salt water as a result of draw down by pumping. The Dakota

water at the State Asylum is now taxed to supply that institution and the State Reformatory. Other favorable supplies of bottom land water, like at Havelock and Waverly, occur at widely separated places near Lincoln. As a rule much of this water is now appropriated.

Our studies indicate that the alluvial water at the Branson place, and in that immediate area has no direct connection through underflow with the water supply in Antelope valley. Also, it is quite certain that there is less connection between the Dakota water there and the Antelope valley than some have claimed.

4. DRIFT HILL WATER.—The hilly uplands in the Lincoln area are formed of a thin, discontinuous mantle of loess, two quite well-defined glacial deposits (Kansan and Nebraskan) and the Dakota formation. The Dakota is the bed rock of this area, except locally at Roca and Bennet. Its upper surface is very uneven, underlying the valleys and standing at irregular heights in the hilly uplands.

The loess (Loveland and Peorian) which mantles some of the hills, carries no water of importance. The drift sheets (glacial deposits) constitute the main mass of the hills. They are well exposed in highway cuts at Belmont, along the D. L. D. west of Emerald, along the Cornhusker near the Seward county line and along the Burlington railroad east of Denton and near Pleasant Dale. Small irregular sand bodies in the Kansan or upper drift sheet carry enough water for farm uses at places.

The Nebraskan drift has very little water. At a few places the eroded and re-deposited drift, known as the Loveland formation, carries enough water for farm supply. In the vicinity of Sprague are water sands of Loveland and older age which give quite strong wells. The water supply here, however, is not built up by underflow from the Big Blue or by underflow from west of that river as has been claimed.

The structural and topographic conditions in most of the Drift Hill area, as near Ceresco and east of Raymond, cause the ground water in the drift deposits and in the eroded remnants of the upper Dakota sandstone to leak out to the drainage ways and not accumulate in volume sufficient for more than weak wells. It has been very difficult to locate rural water supplies in parts of the Drift Hill area near Lincoln.

The water supply in the vicinity of Valparaiso has a very different origin. It is described elsewhere in this report.

5. BRANCHES OF SALT CREEK.—The streams in Salt creek basin vary much as to quality of water. Their discharge is very irregular, ranging between only a few second feet and floods. All of the tributaries of any size, except Salt creek proper and the upper reaches of Oak creek, carry considerable salt and other deleterious compounds. The Burlington railroad uses much of the low stage discharge of Salt creek and there is not enough left for a supplemental city supply without impounding flood water which probably would not be feasible because of the necessary high cost involved in the condemnation of farm, railroad and public property. The flow of Oak creek is not adequate for Lincoln and the objections to flood stage here are about the same as for Salt creek proper.

6. **BIG BLUE RIVER.**—Here is a possible source of water for Lincoln with some points in its favor and certain economic objections all of which are well known.

7. **LOESS PLAIN AREA.**—Most of this area lies between the Big Blue, Platte, Little Blue and Republican valleys. It is capped by 30 to 60 feet of loess and underlain by two thick water-bearing sand and gravel deposits which extend northwestward to and under the middle course of the Platte from near Grand Island westward and reach eastward to the drift deposits. The sand and gravel deposits under the plain have an average thickness of about 200 feet. A silty clay bed separates them as upper and lower zones.

The Loess plain sands hold an interesting geologic relation to the Drift deposits and the Benton shales which outcrop along the Big Blue from Milford south. The interesting geological history here is germane to the subject under consideration. Prior to the first glaciation of eastern Nebraska there were no Loess plains and Drift hills. The area drained eastward through valleys. With the first glaciation, sand and gravel outwash from the ice and inwash from the region west filled these valleys and aggraded a thick deposit over what is now the Loess plains area. The first deposit so formed by in-wash and out-wash alongside the glacier and morainic dam became what we now call the lower sand and gravel sheet. It is of the age of the Nebraskan drift against which it was laid down. Second, when the Nebraskan ice sheet melted back to the north a silty clay deposit was formed on the lower sands and gravels in much of the Loess plain area. Third, with the second or Kansan ice invasion, the second or upper sand and gravel deposit was laid down like that of the first, over the same general area, forming a yet higher level surface on which the loess or wind deposits were formed after the retreat of the Kansan ice sheet. This, then, is the sequence of events connected with the accumulation of the water-bearing sands and gravels which occur so widely west of the Big Blue.

That the sands and gravels and the silty clay layer separating them extend through and under most of the Loess plain and under the Platte bottom between Grand Island and Gothenburg and northwestward therefrom, in some places to the border of the sand hill region, is well shown by many logs of wells. This, our present interpretation of this occurrence, is at variance with earlier conceptions of the condition. It should be known also, as shown by Dr. Lugn, that in much of its middle course, the Platte flows on thin alluvial sands lying on the upper sand just described, rather than on a thick alluvial deposit as some geologists have supposed. The conditions are such as to cause the Platte in the stretch between Gothenburg and below Grand Island to lose enormous quantities of water to underground drainage which is southeastward to the lower course of the Republican and to the Little Blue and Big Blue rivers. This is the main factor in causing the Platte to dwindle to a dry bed in summer. The water table slopes southeastward from the Platte to the rivers just noted. That the water moves through the sands and gravels has been proved beyond question.

There is a vast amount of water in the sands and gravels of the Loess plains, a volume equal to more than fifty times the capacity of

the Pathfinder reservoir. Also, the storage in the sands and gravels in the bottom land of the middle course of the Platte is thought to be equal to about twenty-four times the storage capacity of the Pathfinder reservoir.

Leakage from the Loess plains water-bearing sands to the Little Blue and Big Blue makes them live streams. This is true especially of the West Branch of the Big Blue and it seems safe to state that the water powers of the Blue rivers would be of less importance were it not for the underflow which reaches them from the Platte and probably in part from the sand hills.

Throughout most of its course in Seward and Saline counties, the Big Blue and the lower courses of its main branches have become entrenched down through the drift deposits and the abutting sand and gravel sheets of the Loess plain area to the Benton shales resulting in the capture of the underflow from the west and northwest, thus preventing its movement eastward to the Drift hill area. The loess-covered valley-sides, as near Seward, prevent the maximum escape of ground water to the river. Another factor here is that friction incident to underflow causes the hydraulic gradient to rise westward from the Blue valley, thus limiting the volume of ground water entering the valley and river.

In a few places west of the Big Blue, as at Milford, southwest of Dorchester and west of Beatrice, where the shale bedrock stands somewhat above the river level, the ground water drains from the Loess plain sands and gravels leaving little or no ground water, but this condition does not hold generally in the area west of Seward, at Beaver Crossing and most other places. York, Aurora, Hastings and many other cities and towns draw water supplies from the Loess plain sands and gravels. The wells are strong, due to rapid delivery from thick zones of porous, saturation beds. Among the examples of strong wells are the two used for irrigation near Aurora.

The thick mantle of loess protects the water of the Loess plain area against surface pollution. There is enormous intake of water into the Loess plain sands and gravels from the Platte which flows broadside over many miles of the sand and gravel. This intake should feed or replenish the water supply of the Loess plains so long as the river persists.

The water at Beaver Crossing has enough head to give small flowing wells. It comes from the lower Loess plain sands and not from the Dakota formation, which underlies the Benton shales. Strong pump wells could be installed at Beaver Crossing.

CONCLUSION.—Our studies indicate that ample water is available along the east border of the Loess plain area for Lincoln. However, this water supply is drawn upon by farms and cities, has a relation to a number of water powers, and is sure to become more important for well irrigation. The water supply for Seward was located by the writer at a point far enough back from the Big Blue valley to insure adequate storage and replenishment for the needs of the city. Other locations like this occur west of the Big Blue.

VALPARAISO.—Channel sands and gravels, not very distinctly set off from the lower sand bed of the Loess plain, extend east of the Blue in

northern Seward county and southern Butler county to Lancaster and Saunders counties. They are well developed in the vicinity of Valparaiso where they yield the water of several flowing wells and strong pump wells of which the Union Pacific well at Valparaiso is a good example. Just how much water could be drawn from the Valparaiso area for Lincoln is not known. The gravel is 50 to 100 feet in thickness; the water is of good quality and in greater abundance than was formerly estimated. No doubt most of this water comes from the Platte.

8. **TODD VALLEY.**—This area, 8 or 10 miles wide and about 28 miles long, extends across Saunders county from between Morse Bluff and Cedar Bluffs southeastward to between four miles south of Yutan and Ashland. It was described and named by the writer several years ago. The valley represents an ancient channel of the Platte partly filled with a comparatively thick water-bearing sand and gravel on which the Peorian loess was deposited. The water of Todd valley comes from local rainfall, and in part by intake from the present Platte in a narrow stretch between Morse Bluff and Cedar Bluffs.

When Todd valley was studied and named I learned about the buried water-bearing gravels but had no thought that they might supply Wahoo. A few years later, Dean O. V. P. Stout, who had been invited to extend the water supply of Wahoo, came to the writer for assistance. It was then realized that Todd valley, just east of the city, would be the place to secure the water. The city developed this source of supply.

CONCLUSION.—Although there is much ground water in Todd valley, it is my opinion that it should be conserved for present demands and not tapped by Lincoln, because the amount of water for Lincoln might be more than could be drawn from this source without interfering with the local needs of the valley.

9. **PLATTE VALLEY.**—This valley has three well-defined courses or stretches, as follows:

- (1) From the mountains to North Platte.
- (2) From North Platte to Columbus.
- (3) From Columbus to the Missouri.

In the first course, the geological and topographic conditions cause the water diverted for irrigation, except that lost by evaporation and used by crops, to pass into ground storage and back to the river as underflow, called "return flow". In the second course, as heretofore noted, the physical conditions cause maximum ground storage in the bottom land and underdrainage southeastward therefrom. Much of the river becomes ground water and underflows at all seasons of the year, but the relation of the river to storage and underflow is most noticeable during periods of drouth when there is most evaporation and least rainfall, at which time the river dwindles in part through evaporation, but largely on account of its loss to ground water storage, leaving a dry bed just above the water table.

The maximum ground storage in the middle course of the Platte is attained during high stages of the river, yet the volume of water in the ground is large at all times. This ground water is used for sub-irrigation, well irrigation, domestic and municipal supply. The State Geological Survey and the State Water Survey, in co-operation with the United States Geological Survey, are making a close study of the

ground water resources of this course of the Platte. The surveys are to recommend methods for storing flood water in the ground and a plan whereby, through storage and drainage, the ground water level can be held at the optimum depth for agricultural development.

CONCLUSION.—It would be possible to divert water from the Platte at some point between Grand Island and Kearney, when there is discharge, and draw abundant supply from the underflow of the valley at all times of the year, and carry it to Lincoln by gravity pipe line. However, this seems not the most feasible thing to do because the supply from the river would not be dependable all year, the underflow could be tapped much nearer Lincoln, and there is a growing, useful utilization of this water in the area with no other source of supply.

LOWER COURSE OF PLATTE VALLEY.—The third and lowest course of the Platte is the Loup-Elkhorn-lower Platte. This composite river has a large, uniform discharge from sandhill storage, is supplied from an area of heavier rainfall, and the geological and topographic conditions direct most of both the surface and underflow to the valley without much leakage loss. It, like the North Platte valley, is a water conservancy basin. Water, ample for the needs of Lincoln, could be taken from this course of the river and valley.

Although the bottomland of the lower course of the Platte is somewhat narrower and the water-bearing deposits average thinner than in the middle stretch of the valley, there is a large volume of ground water close to the river from which heavy draw down by pumping would increase the underflow from the river in rate of movement related to the coarseness of the water-bearing materials and the distance from the river.

CONCLUSION.—Our surveys show that the bedrock floor of the Platte between Columbus and Ashland is quite uneven and that the water-bearing sands range between 25 and 100 or more feet in thickness, averaging about 70 feet. This means that before installing a water supply for Lincoln, as northeast of Ashland, the valley should be traversed with several lines of soundings to determine the exact cross-section, the most favorable place to intercept the maximum underflow, and the location of a water supply that could be protected against all hazards and against surface pollution. Samples of water should be taken from different depths for chemical analysis for comparison with other possible supplies. Surface study and closely placed soundings should be made in order to make sure no shallow, slough-like, surface drainage ways and mucky, buried, old channels are on or in the prospective water ground. Also, the wells should be tested.

A strong point in favor of locating the Lincoln water supply some where northeast of Ashland seems to have been overlooked. It is that the water there flows from the state without much chance for other important beneficial use. Such location, would, in this respect, conform to the plan of the State and Federal governments to conserve and utilize the water resources with least interference and for the greatest general good.

PURPOSE OF REPORT.—This paper is a plain statement of the geologic and water conditions relating to the water problem at Lincoln, made in the hope of contributing to the solution of the problem. No attempt is

made and no attempt is to be made by either the State Geological Survey or the State Water Survey to influence the city officials in favor or against any possible water supply. The obligation is with the Mayor and the City Council and I am sure that the trust placed in them by the citizens will result in the correct solution of the problem.

CONCLUSIONS

1. A water supply ample for present and probable future needs of the city is absolutely necessary.
2. Lincoln has outgrown the established water supply and there seems to be no new and adequate source of supply in the immediate vicinity of the city to meet the demands incident to city growth.
3. Most of the water supply is drawn from storage in the sands of the Dakota group of beds into which salt water invades from the west as a result of heavy pumping, thus decreasing the storage area for the better ground water. All of the water storage ground in Lincoln is underlain by salt-bearing formations at comparatively shallow depths.
4. The ground water in storage at the pump areas of the city is being exhausted faster than replenished as shown by the lowering water table and the salt water invasion.
5. The ground water used by the city is quite local in origin. It is supplied from rainfall, surface drainage and underflow from nearby areas south and southeast. Little or none of it comes through the Dakota by long distance underflow from the far west as some have supposed.
6. The small supplemental water supplies in the close vicinity of Lincoln are thought not to be dependable for future needs.
7. The sands and gravels in the vicinity of Valparaiso carry more water of good quality than we formerly supposed.
8. The Big Blue River, fed in considerable part by underflow of sand and gravel beds to the west, might be tapped for the supplemental supply.
9. The vast volume of ground water in the Loess plain area would yield ample water for Lincoln.
10. The Platte river would yield an abundant supply at some point between Columbus and Ashland.
11. The ground water along the lower Platte, as northeast of Ashland, could be drawn upon for an abundant supply.
12. The location and development of the most feasible supplemental water supply for the city rests with the Mayor and the City Council. This will require special technical investigation as to source, chemical composition, volume and cost of water.