NE Water Use

VIII. NEBRASKA WATER USE

To understand this concept, picture a person squeezing a toothpaste tube. If you squeeze at the bottom of the tube, toothpaste comes out the other end, even though the toothpaste hasn't moved through the entire length of the tube. Groundwater responds to changes in water table elevations and pressures in a similar fashion.

Because of the lag effect, a pumping well's impact on a stream will not be noticeable for some time after the well has started pumping, and it will be even longer before the entire impact of the well arrives at the stream.

For example, the chart below depicts the modeled impacts of well pumping on a stream. The first part of the curve shows the increased amount of stream depletion caused as well development increases. After the year 2000, the number of pumping wells was held constant. Nevertheless, the stream depletion continues to increase until a new equilibrium is reached.

In reality, it is not easy to observe the impact of wells on stream flow. Often, variations in precipitation, pumping patterns and stream flow are such that only after many years can the impacts of pumping on stream flow be observed.

A long wet period lowers the demand for water, can partially refill available aquifer storage and mask the impacts of pumping. In contrast, dry periods, like the current drought, highlight the impacts of pumping.

In some cases, the impacts of pumping on groundwater tables are noticeable. But in others, changes in water-table elevation cannot be seen until stream flows have significantly declined.

Finally, not all the water diverted from a stream or pumped by a well is consumed and removed from the integrated surface-water/groundwater system.

Only the water that is actually consumed through evaporation or evapotranspiration is removed. The remaining portion of what was pumped returns to the system as surface-water runoff to a stream or as recharge to an aquifer. For this reason, what really matters is how much water is consumed.

For example, if the consumptive use of an acre of corn is 24 inches in a given year, 10 inches is supplied by local precipitation and the remaining 14 inches is supplied by pumping irrigation water. It doesn't matter significantly if 18 inches or 25 inches of water is pumped on to the field. In either case, only 14 inches will be consumed. The remaining 4 to 11 inches will return to the system as surface-water runoff or recharge to the aquifer.

To conserve water, it is the amount of water consumed, not just the amount of water pumped, that must be reduced.

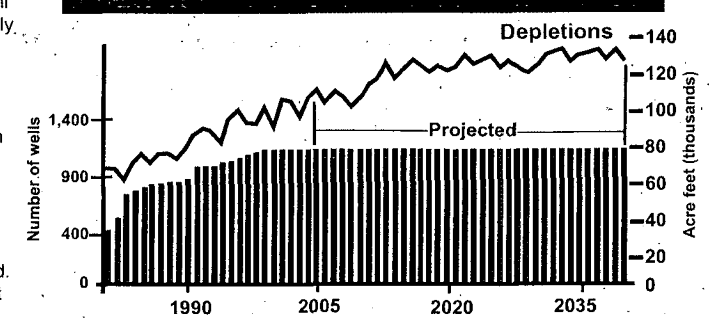
Thus, unless the actual consumption of water is decreased, increasing the efficiency of an irrigation system will not automatically decrease the consumptive use of water.

Of course, increasing the efficiency of an irrigation application system has many other benefits, such as decreasing fuel and fertilizer input costs and protecting water quality.

In summary, under LB 962 where groundwater and surface water are hydrologically connected, the stream-aquifer system must be treated as one integrated resource. It is clear that if water is consumed, water will be removed from the system. There is no free lunch.

It is equally clear that the physical differences in how the use of hydrologically connected surface water and groundwater impact the system require different management techniques.

The management tools for both groundwater and surface water must, however, be coordinated to reach the common goals and objectives for the combined resource.



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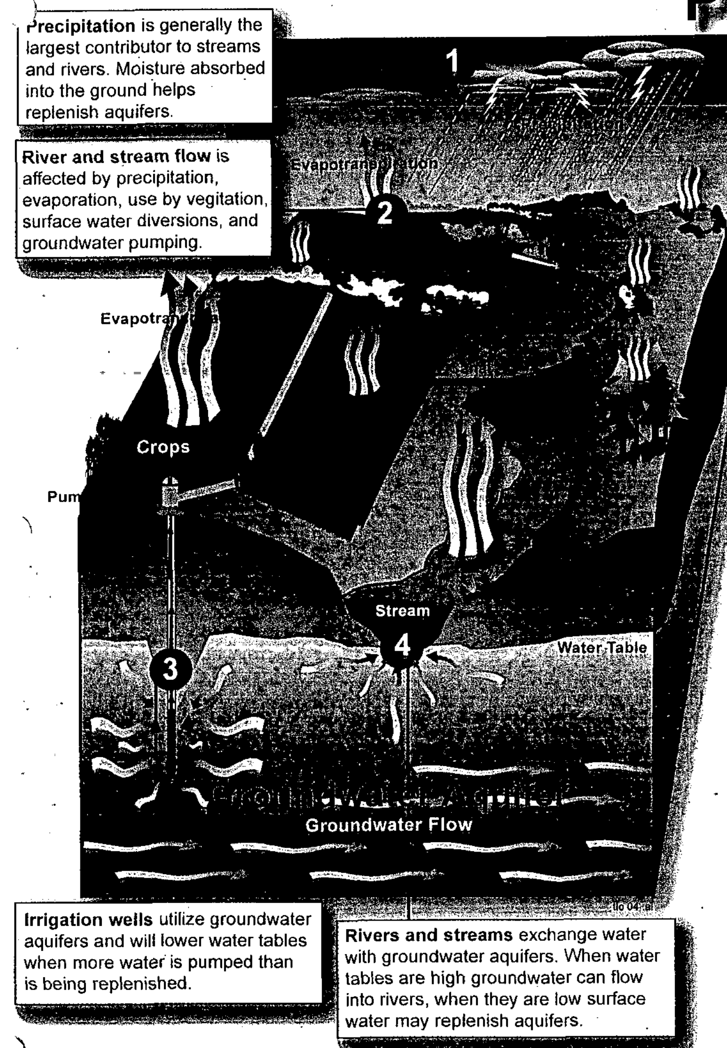
Groundwater Pumping and Stream Flow



Nebraska has reached a crossroads in the use of water, our most important natural resource. In the last two decades, demands on water use have reached the limits of the supply in some of Nebraska's river basins.

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By Roger K. Patterson, P.E., Director,
Nebraska Department of Natural Resources
and
Ann Bleed, Ph.D, P.E., Deputy Director

Nebraska has reached a crossroads in the use of water, our most important natural resource. In the last two decades, demands on water use have reached the limits of the supply in some of Nebraska's river basins. Disputes have arisen internally and with our neighboring states. Surface-water appropriators on the Republican River and Platte River systems have raised concerns that groundwater pumping has depleted their surface-water supplies.

In 1998, Kansas sued Nebraska, complaining that Nebraska's groundwater pumping was causing Nebraska to be out of compliance with the 1943 Republican River Compact. In 2000, the U.S. Supreme Court ruled that the compact regulates portions of groundwater use. In 2001, litigation over the impact of groundwater pumping on surface-water supplies was initiated in regard to Pumpkin Creek, a Panhandle tributary of the North Platte River. The common thread in each of these situations is the hydrologic connection between surface water and groundwater and how to manage this combined resource.

In response to these growing concerns, the Legislature formed a 49-member Water Policy Task Force. In 2004, the Legislature adopted the task force's recommendations and **passed Legislative Bill 962**: LB 962 addressed the issue of managing **hydrologically connected water supply and demand** by amending the Groundwater Management and Protection Act to provide for proactive, integrated management of hydrologically connected surface and groundwater supplies. Under Nebraska law, the local natural resources districts have been responsible for managing groundwater use. The Nebraska Department of Natural Resources has been responsible for administering surface-water supplies and ensuring the state's compliance with interstate compacts. LB 962 did not change this basic institutional structure. LB 962 does require that the Department of Natural Resources and the NRDs work together **to jointly develop and implement integrated management plans to manage hydrologically connected surface-water and groundwater supplies.**

The key to developing a successful integrated management plan is an understanding of how the state's groundwater supplies interact with the state's surface-water supplies. Unlike surface-water flow, which is relatively easy to understand because it is readily observed and easily measured, groundwater flow is hidden and difficult to measure. Groundwater moves much slower than surface water, often only a few feet per year. This slow movement of water occurs through the pore spaces between the sands, gravels and other subsurface materials below the ground. These materials that store and transmit water are called aquifers.

To visualize an aquifer, think of a sandbox filled with sand. Now, pour water into the box. The water fills the empty spaces between the grains of sand. That is what happens with groundwater in an aquifer. If there is a drain hole on the side of the sandbox, water will flow toward the hole until the sand is drained. The drain is like a river. If you dig a hole in the sand in the middle of the box, you may see water in the hole. If you scoop water out of the hole with a cup, water will move into the hole from the surrounding sand. That hole is like a pumping well. Scooping water out of the hole in the sand reduces the amount available to go out the drain hole.

Water in Nebraska's streams comes from two sources: (1) runoff from local precipitation and, in some cases, Rocky Mountain snowmelt; and (2) discharge from groundwater aquifers. While there are multiple aquifers in Nebraska, the High Plains Aquifer complex is the primary source of groundwater. This groundwater reservoir is mostly comprised of the Ogallala formation and overlying sands and gravels. The Ogallala formation itself contains a complex mixture of sands, gravels, sandstones, silts and clays, much of which is well-suited for holding and moving groundwater. This formation was deposited over millions of years. In the natural state, water is removed from the groundwater system by evaporation, by consumption by plants and animals or by flowing out of the system to a stream. People also remove water from the integrated system, either by diverting it directly from a stream or by pumping it from wells (see graphic).

Much of what we know about groundwater movement comes from extensive geologic and climatological investigations over the last 100 years. In addition, we use groundwater models to further our understanding of the system and to make estimates of how much water might be available in the future under different management scenarios. These groundwater models use available information such as groundwater levels, precipitation, pumping and stream flow to calculate water levels and flows everywhere in the aquifer. The model is constructed so that it matches all the real-world observations of the groundwater system.

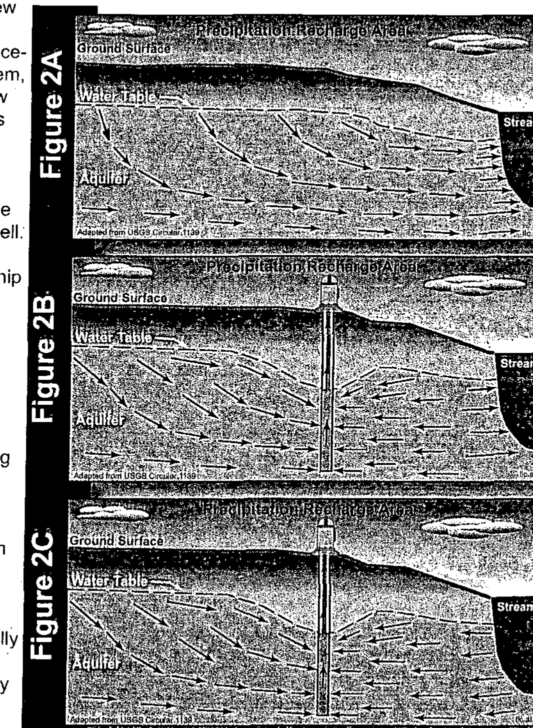
How does water use affect the overall supply?

Though different in many respects, there are a number of basic principles common to both surface-water and groundwater systems.

- **First**, where groundwater aquifers are in hydrologic connection with surface-water streams, the two must be viewed as a single, integrated system. The addition of water to either the aquifer or the stream will result in an increase to the other over time. Likewise, the removal of water from either the aquifer or the stream will result in a decrease to the other over time. The integrated system constantly seeks a state of balance.
- **Second**, as a general rule, the amount of water entering any system over the long term must equal the amount leaving the system, including any change in the amount stored in the system. In the shorter term, if inflows exceed outflows, the excess is stored and the water levels in the aquifer rise. Conversely, if the outflow is greater than the inflow to the system, water levels in the aquifer decrease.
- **Most importantly**, there is not an unlimited supply of water in this system.

We all know that large portions of the state do not receive a lot of rain. In these areas, pumping may cause outflows from the integrated system to exceed the inflows to the point where streams dry up and wells go dry. In other words, if pumping causes the outflow from the system to exceed the inflows, then other outflows such as stream flow, evapotranspiration (the use of water by plants, especially trees and shrubs in river valleys) and groundwater flow to other parts of the aquifer will be reduced until a new equilibrium is achieved.

In an integrated surface-water/groundwater system, depletions to stream flow can occur either by wells intercepting water that otherwise would have flowed to the stream or by causing water to move from the stream to the well. **Figure 2A** diagrams a stream-aquifer relationship that is fairly typical of many of Nebraska's streams. If a well starts removing water from the aquifer **(Figure 2B)**, the well will intercept water that otherwise would have resulted in providing water to the stream. As the well continues to pump, more water is removed from the system and less water reaches the stream. Eventually, if the pumping continues **(Figure 2C)**, water actually will flow from the stream toward the well. Generally speaking, both surface-water diversions and groundwater pumping remove water from the system. But the short term impact of each on the stream can be dramatically different.



A surface-water diversion immediately depletes the stream by the total amount diverted. When the diversion is stopped, the depletion to the stream stops immediately.

When a well starts to pump, there is also an immediate depletion to the stream caused by the instantaneous dropping of water levels everywhere in the aquifer. But although the drop in the water table is substantial close to the well, the drop decreases away from the well until it is so tiny it cannot be observed.

Also in contrast to a surface-water diversion, after the well is turned off, depletions to the stream will continue to increase, often for many years, before they start to decrease.

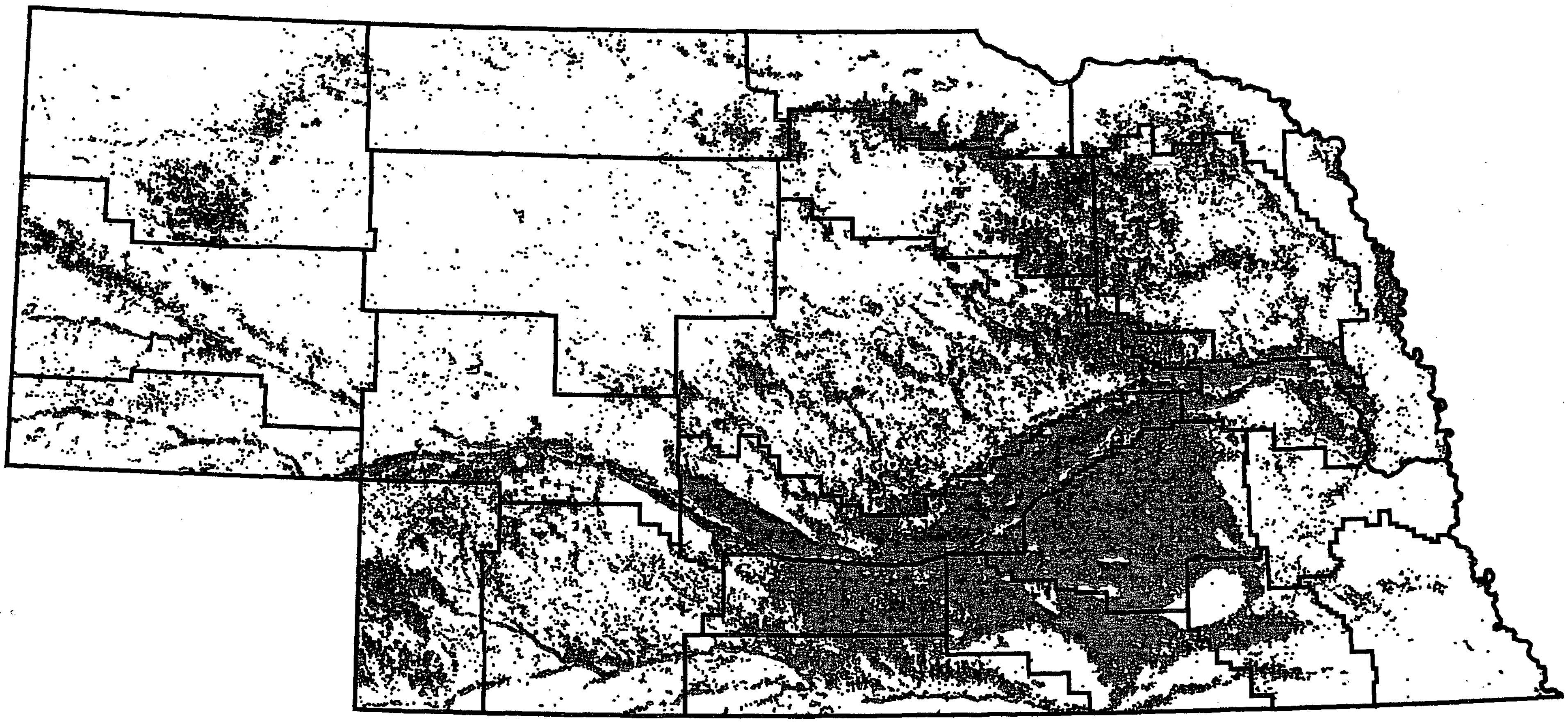
For example, in a system like the Republican River Basin, a single well far from the river may not draw any significant amount of water from a river for 25 years and may take only 20 percent of its water from the river after 100 years. The well, however, will keep on taking water from the river hundreds of years after pumping stops.

This lag between the time water is pumped from the groundwater and the time the depletion is observed in streams is referred to as the "lag effect."

Some people assume that the lag effect is the result of the velocities at which water moves through the groundwater system; that is, if the groundwater velocity is 100 feet per year, it will take 50 years to see the impact on a stream of a well 5,000 feet from the stream.

This is not the case. An individual water molecule does not have to move from the stream to the well to cause an impact on the stream. Changes in water table elevation and aquifer pressure, not the velocity of water, determine when and how much a well will affect the stream.

Active Irrigation Wells
November 5, 2004



Source: Nebraska Dept of Natural Resources Ground Water Database

Nebraska Dept. of Natural Resources
jshafer, 11/5/2004

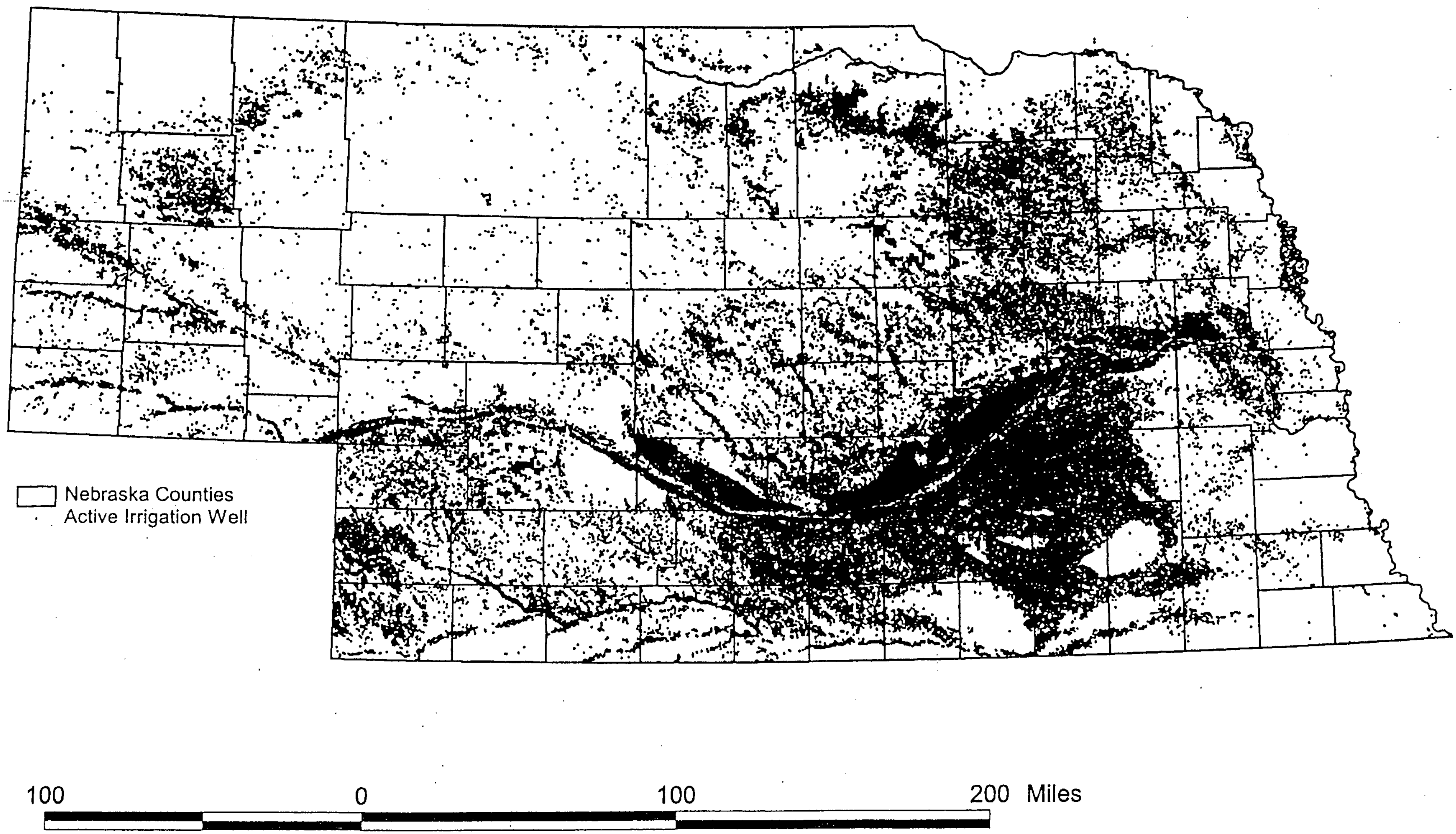
ESTIMATED ACRES IRRIGATED IN NEBRASKA

Year	Surface Water	Groundwater	Total
1860	9.000	---	9,000
1890	12,000	---	12,000
1900	150,000	1,000	150,000
1920	450,000	1,000	450,000
1940	500,000	40,000	540,000
1950	600,000	470,000	1,070,000
1960	850,000	1,650,000	2,500,000
1970	1,000,000	3,000,000	4,000,000
1980	1,000,000	6,200,000	7,200,000
1990	1,000,000	7,000,000	8,000,000
2000			8,150,000

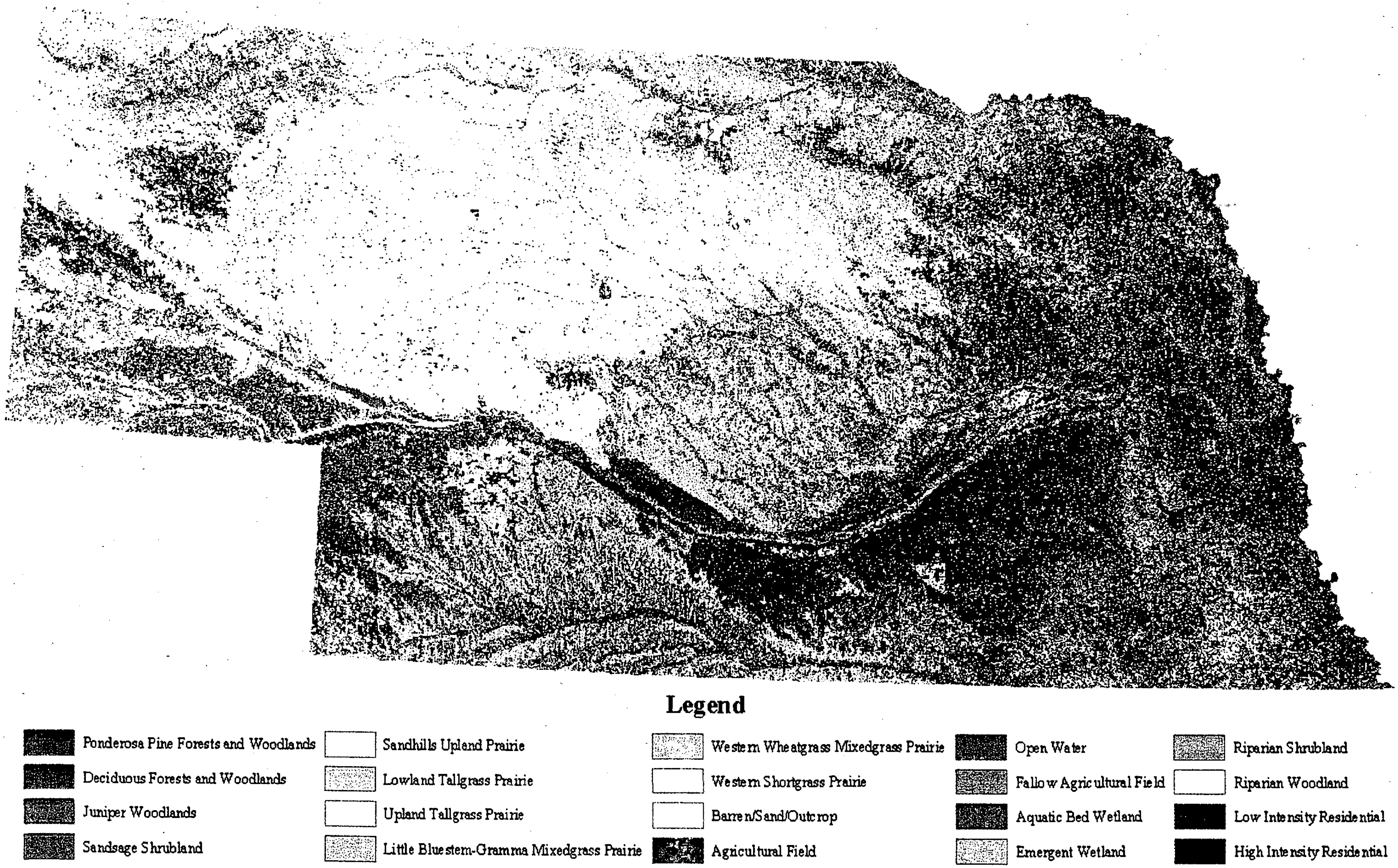
- The totals represent acres that have wells or surface-water rights that could be irrigated if conditions warrant. Some duplication after 1940 occurs because many acres served by surface water also receive well water.

Modified From: “Water Availability and Use” by Vincent H. Dreeszen in “Flat Water: A History of Nebraska and its Water”, Resource Report No. 12, Conservation and Survey Division, University of Nebraska, March 1993. Material found on page 84. Only modification is addition of 2000 irrigated acreage total from Nebraska Agricultural Statistics.

Nebraska Active Irrigation Wells



Nebraska Gap Land Cover Classification



Source: CALMIT-University of Nebraska Lincoln

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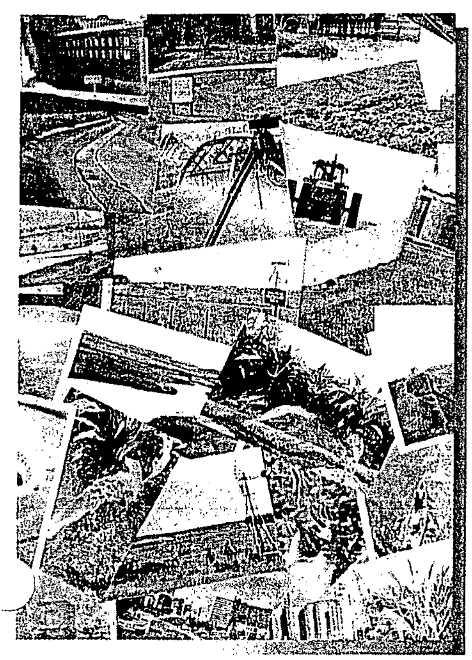
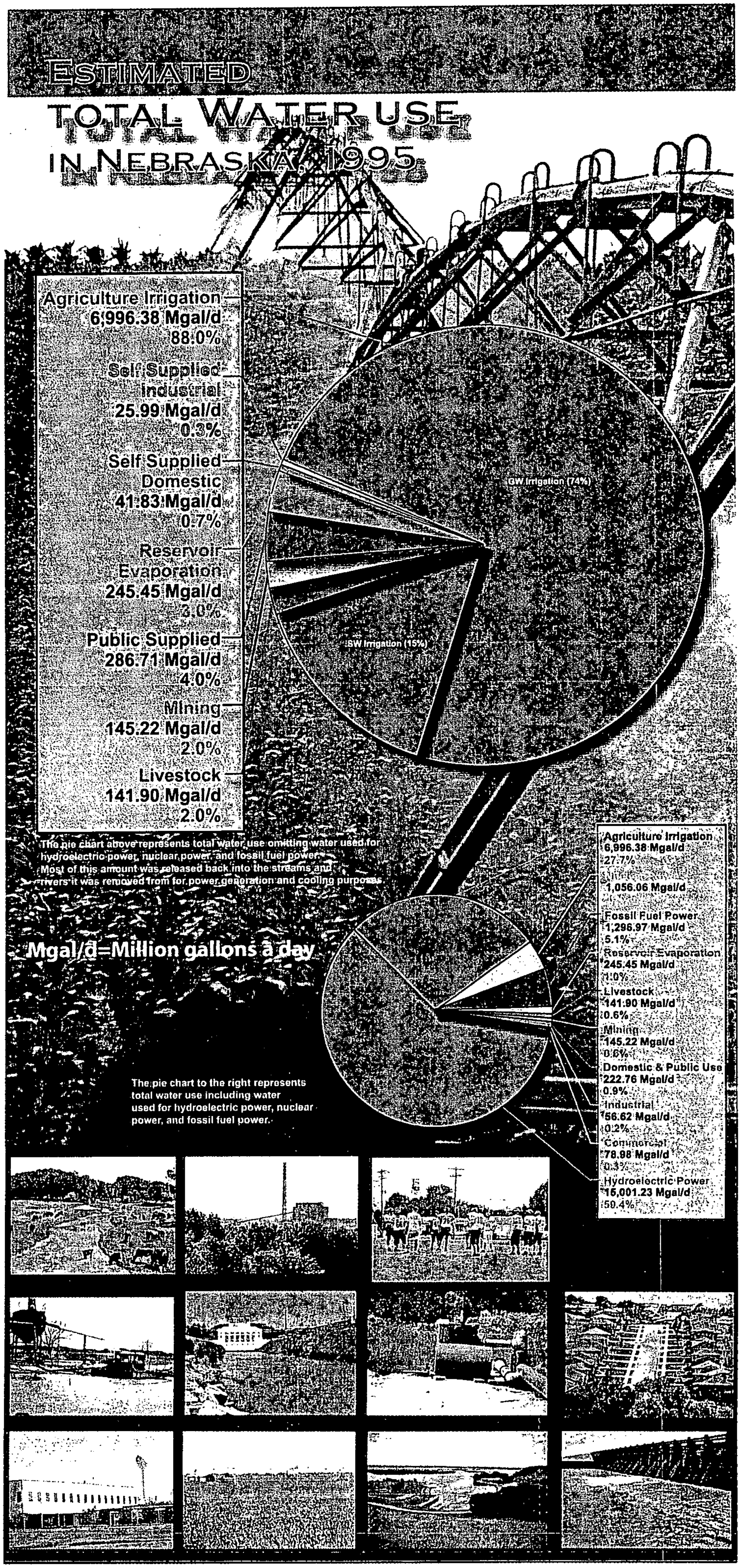
WATER USE

Vast quantities of surface and groundwater are used in Nebraska for a wide range of purposes. Surface water is diverted and withdrawn from streams and reservoirs for offstream uses, including hydroelectric power generation and irrigation. It is also used in streams, reservoirs, and lakes for hydroelectric power generation, fish and wildlife uses, livestock watering, and recreation. Groundwater is used for irrigation, water supply for humans and animals, and commercial and industrial uses. In some cases groundwater contributes flow to surface water, as either a deliberate or unintended result of the original use. Groundwater applied to fields for irrigation may infiltrate into aquifers or be discharged into rivers. Also, some groundwater used for public water supply is returned to streams via wastewater treatment plant discharge.



Source: Natural Resources Commission, Estimated Water Use in Nebraska-1995. April 1998



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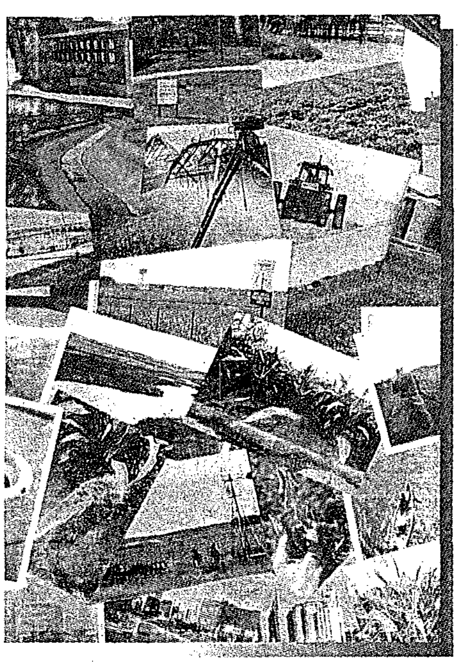
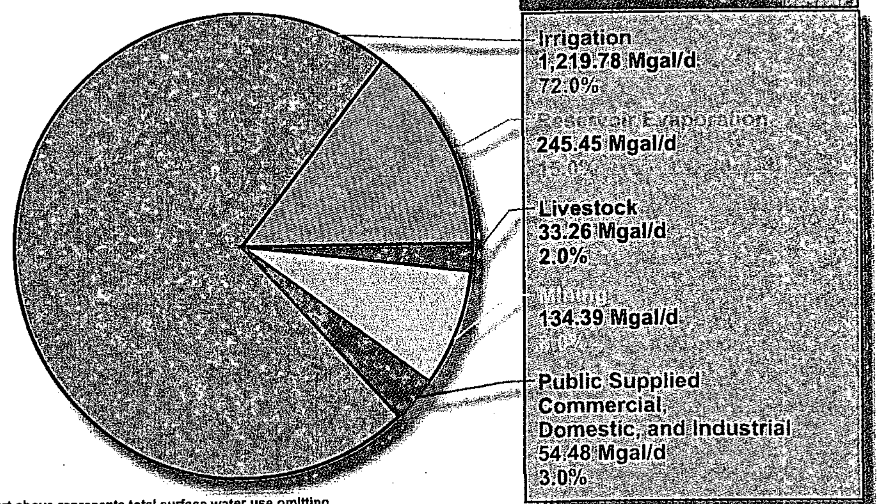
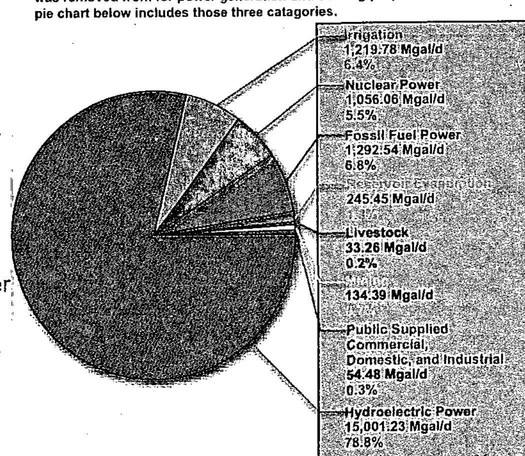


Source: Natural Resources Commission, Estimated Water Use in Nebraska-1995. April 1998

ESTIMATED TOTAL SURFACE WATER USE IN NEBRASKA, 1995



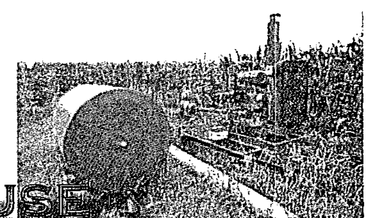
The pie chart above represents total surface water use omitting water used for hydroelectric power, nuclear power, and fossil fuel power. Most of this amount was released back into the streams and rivers it was removed from for power generation and cooling purposes. The pie chart below includes those three catagories.



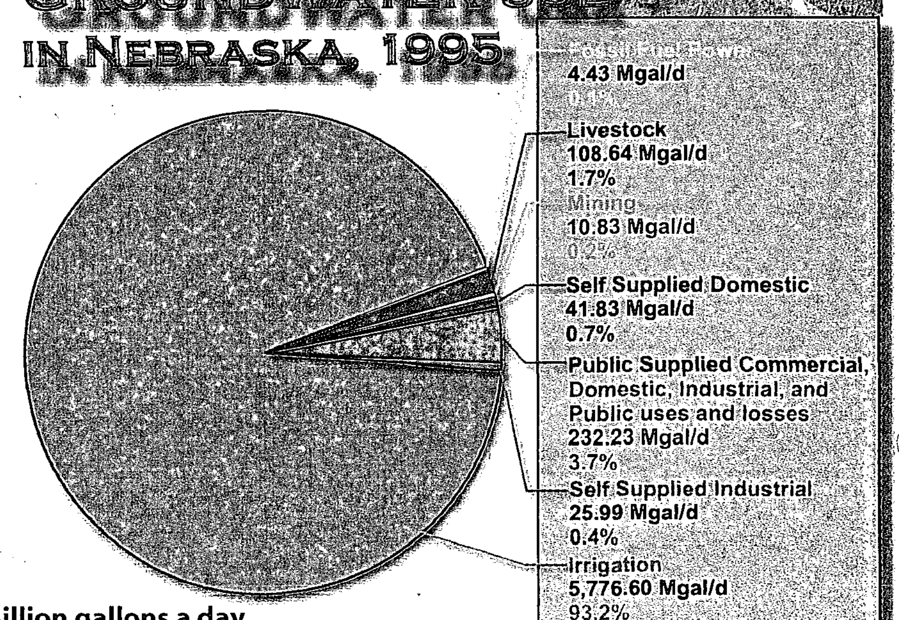
WATER EQUIVALENTS TABLE

1 Cubic foot	7.48 gallons	62.4 lbs. of water
1 Acre-foot	43,560 cubic feet	325,851 gallons
An acre-foot of water covers 1 acre of land 1 foot deep		
1 cubic foot per second (cfs)		448.8 gallons per minute
1 cfs		646,272 gallons per day
For 24 hours		1.984 acre-feet
For 30 days		59.5 acre-feet
For 1 year		724 acre-fe[illegible]
1 million gallons		3.07 acre-fee[illegible]
1 million gallons per day (mgd)		1,121 acre feet per year
1,000 gallons per minute (gpm)		2.23 cfs
1,000 gpm		4.42 acre-feet per day
$.10 per 1,000 gallons		$32.59 per acre-foot

An acre-foot supplies a family of 5 for 1 year.
An acre-foot irrigates ½ acre of corn in most areas of Nebraska



ESTIMATED TOTAL GROUNDWATER USE IN NEBRASKA, 1995



Mgal/d=Million gallons a day

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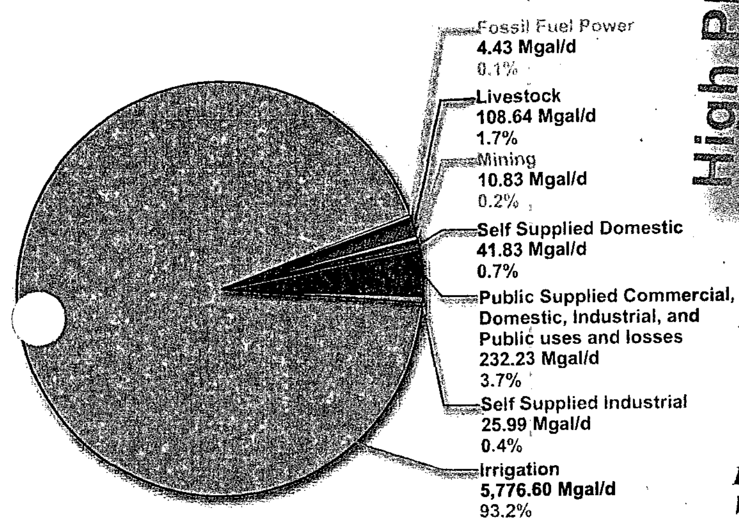
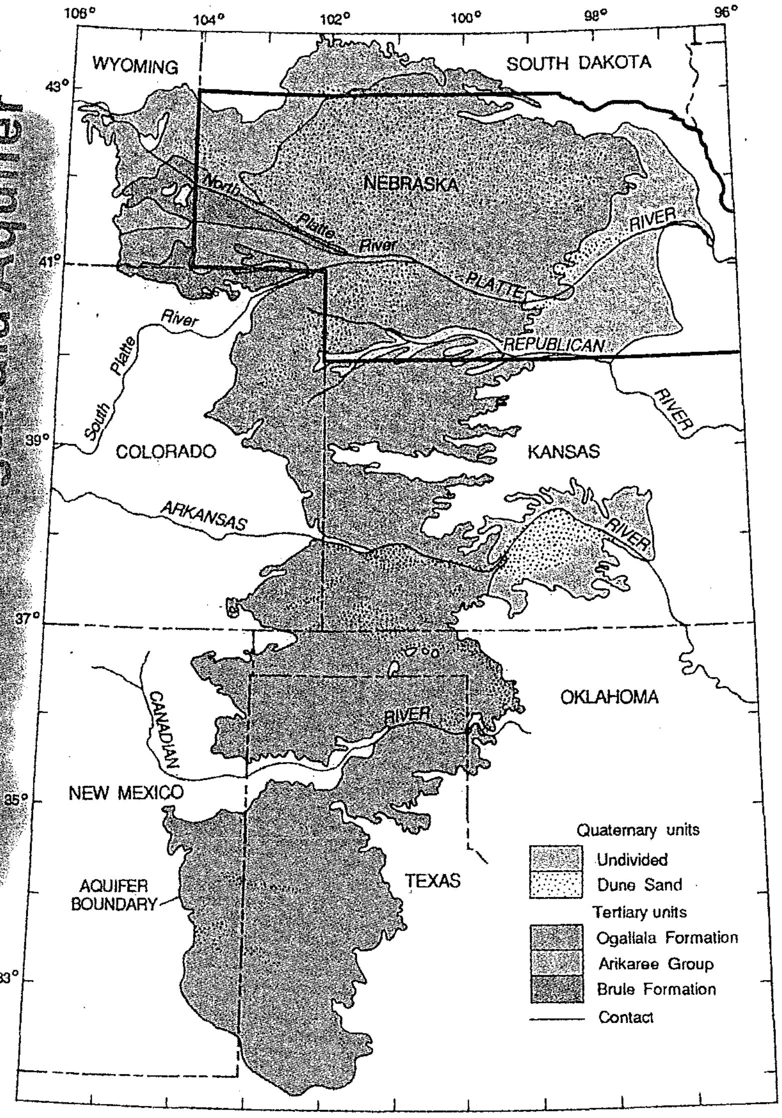
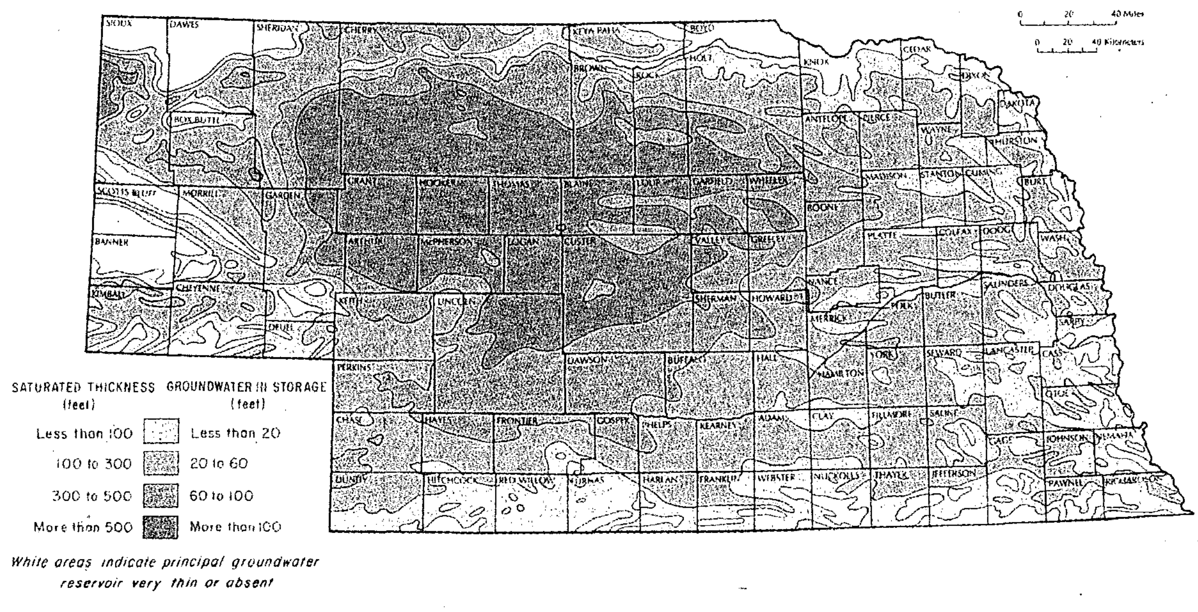
Estimated Total Groundwater Use in Nebraska, 1995



High Plains Ogallala Aquifer



Distribution of principal geologic units in the High Plains aquifer (after Weeks and others, 1988).



Saturated Thickness of the Principal Groundwater Reservoir

Estimated Groundwater in Storage
2,130,000,000 Acre-feet

Source Conservation and Survey Division
University of NebraskaLincoln

COMPARATIVE STATE IRRIGATION STATISTICS

Table 1 – Top Dozen States in Irrigated Acreage – 2000

State	Irrigated Acreage Rank	Irrigation Withdrawal Rank	% of Total U.S. Irrigated Acreage	% of Total Irrigation Withdrawals That Were From Groundwater
California	1	1	16.3%	38.0%
Nebraska	2	4	12.6%	84.4%
Texas	3	5	10.5%	75.3%
Arkansas	4	7	7.3%	82.3%
Idaho	5	2	6.1%	21.8%
Colorado	6	3	5.5%	18.9%
Kansas	7	13	5.3%	92.4%
Oregon	8	8	3.5%	13.0%
Florida	9	11	3.3%	50.8%
Montana	10	6	2.8%	1.0%
Washington	11	14	2.5%	24.6%
Georgia	12	19	2.5%	65.8%
			78.3%	

Source: Estimated Use of Water in the United States in 2000 – U.S. Geological Survey Circular 1268

Table 2 – Top Dozen States in Irrigation Withdrawals – 2000

Rank for Irrigation Withdrawals		% of Total U.S. Irrigation Withdrawals	% of Total Withdrawals That Were From Groundwater
1.	California	22.3%	38.0%
2.	Idaho	12.5%	21.8%
3.	Colorado	8.3%	18.9%
4.	Nebraska	6.4%	84.4%
5.	Texas	6.3%	75.3%
6.	Montana	5.8%	1.0%
7.	Arkansas	5.8%	82.3%
8.	Oregon	4.4%	13.0%
9.	Arizona	3.9%	50.9%
10.	Wyoming	3.3%	9.2%
11.	Florida	3.1%	50.8%
12.	Utah	2.8%	13.6%
		85.0%	

Source: Estimated Use of Water in the United States in 2000 – U.S. Geological Survey Circular 1268

Table 3 –State Water Withdrawal Rankings – 2000

Surface Water Withdrawals for Irrigation - 2000		Groundwater Withdrawals for Irrigation - 2000		Total Fresh Water Withdrawals (All Types – Not Just Irrigation) - 2000	
California	21,172	California	13,030	1.	California
Idaho	14,899	Nebraska	8,335	2.	Texas
Colorado	10,373	Arkansas	7,313	3.	Idaho
Montana	8,816	Texas	7,301	4.	Illinois
Oregon	5,926	Idaho	4,179	5.	Colorado
Wyoming	4,582	Kansas	3,853	6.	Nebraska
Utah	3,798	Arizona	3,089	7.	Ohio
Arizona	2,980	Florida	2,449	8.	Tennessee
Washington	2,565	Colorado	2,426	9.	Louisiana
Texas	2,386	Missouri	1,550	10.	Indiana
Florida	2,364	Mississippi	1,472	11.	Michigan
New Mexico	1,826	New Mexico	1,382	12.	Pennsylvania
Nevada	1,725	Oregon	890	13.	Alabama
Arkansas	1,580	Louisiana	889	14.	North Carolina
Nebraska	1,535	Georgia	842	15.	Montana

Note: Amounts are in thousand acre feet per year
Source: Estimated Use of Water in the United States in 2000 – U.S. Geological Survey Circular 1268

Table 4 – Western States Irrigation in Comparison to Nebraska – 2000

State	Irrigated Acreage As a % of Nebraska Irrigated Acreage	% of Total Irrigation Water Withdrawals That Were From Groundwater
California	129.2%	38.0%
Nebraska	**100.0%**	**84.4%**
Texas	83.0%	75.3%
Idaho	48.0%	21.8%
Colorado	43.5%	18.9%
Kansas	42.3%	92.4%
Oregon	27.7%	13.0%
Montana	22.0%	1.0%
Washington	20.1%	24.6%
Utah	18.0%	13.6%
Wyoming	14.8%	9.2%
New Mexico	12.8%	43.0%
Arizona	12.5%	50.9%
Nevada	8.3%	26.9%
Oklahoma	6.5%	78.8%
South Dakota	4.5%	36.7%
North Dakota	2.9%	49.8%

Source: Calculated from estimates in: "Estimated Use of Water in the United States in 2000", U.S. Geological Survey Circular 1268, USGS 2004