Section 22 Study

Planning Assistance to States

Evaluation of Lake Levels for Carter Lake, Iowa and Nebraska

Hydrology Analysis

August 1985

HYDROLOGY ANALYSIS

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Authority and Purpose

This report presents the results of the hydrologic study of Carter Lake, Iowa and Nebraska, which was done under the authority of Section 22 of Public Law 93-251, Water Resources Development Act of 1974, Planning Assistance to States. The hydrologic analysis was conducted by the Omaha District Corps of Engineers during the period from 1984 to 1985 at the request of the States of Iowa and Nebraska. Section 22 provides the authority for the Corps of Engineers to cooperate with a state and provide assistance in preparing comprehensive state water plans for the development, use, and conservation of available water resources.

The purpose of the hydrology study was to determine the cause of fluctuating water surface levels in Carter Lake, which have had an adverse impact on recreation and have caused some property damage due to bank erosion in the area. The effects on future Carter Lake levels caused by the Storz Freeway, which is under construction, and the planned diversion of the Eppley Airfield runoff into the Missouri River were investigated. Finally, a strategy for controlling the level of Carter Lake in the future is discussed.

Climate

The Carter Lake drainage basin is located in a typical subhumid climate. Average annual precipitation is about 30 inches per year and average lake evaporation is about 40 inches per year, as shown in Table 1.

Table 1
Carter Lake Average Monthly Precipitation and Evaporation

	Avg. Precip. (inches)	Avg. Lake Evap. (inches)	Avg. Carter Lake Volume Loss Due to Evaporation (acre-feet)
Jan	0.77	0.89	24
Feb	0.91	1.04	28
Mar	1.91	1.56	42
Apr	2.94	2.08	75
May	4.33	5.58	149
Jun	4.08	6.26	167
Jul	3.62	6.47	172
Aug	4.10	5.58	149
Sep	3.50	4.10	110
Oct	2.09	3.35	90
Nov	1.32	1.73	46
Dec	0.84	1.12	30

Description of Carter Lake Drainage Basin

Carter Lake, a horseshoe-shaped oxbow of the Missouri River, is bounded by the Missouri River on three sides. It is located in northeast Omaha adjacent to Eppley Airfield and is primarily used for recreational purposes. No streams contribute to Carter Lake; however, Carter Lake drains approximately 1,925 acres (not including 320 acres of lake) of both urbanized and undeveloped land. Before the addition of the Omaha north interceptor sewer, Carter Lake also drained land situated along the high bluffs located just west of its present drainage basin.

Present Conditions. The soil type is part of the Albaton-Haynie association which consists of a deep, poorly drained, nearly level clayey and silty soil. Land use classification within the basin has been divided into four different categories with each land use consisting of one or several different soil series. The land uses along with their respective soil series is shown in Table 2 below.

Table 2
Carter Lake Land Use and Soil Types

		Approximate Area (acres)	Percent Impervious (%)
1.	Undeveloped Lands		
	a. Albaton (Ab)	192	10
	b. Albaton (Ac)	403	10
	c. Sarpy (Sp)	223	10
2.	Residential Lands		
	a. Albaton (Ab)	143	30
	b. Carr (CA)	283	35
3.	Airport		
	a. Cut and fill	626	60
4.	Commercial		
	a. Cut and fill	55	40
		1,925	Basin avg. 32.5 %

Planned Development. The future conditions within the drainage basin consist of the addition of the Storz Freeway and the proposed diversion by Eppley Airfield of storm runoff from Carter Lake to the Missouri River. The proposed diversion by the Airfield would eliminate item No. 3 in the table shown above. This would decrease the contributing drainage area to 1,299 acres and would also decrease the percent impervious to 18.9 percent.

Hydrologic Analysis

The hydrologic analysis conducted by the Corps of Engineers consisted of two parts: (1) determination of the causes leading to high and low water conditions and (2) the future effects that the construction of the Storz Freeway and the proposed diversion of Eppley Airfield storm runoff from Carter Lake into the Missouri River would have on lake levels. In order to try to delineate the causes of high water conditions in the lake, lake level data were obtained from the City of Omaha, so that a time history plot showing lake levels, Missouri River stages, and precipitation could be constructed. In addition, readings from Corps of Engineers piezometers located along Ninth Street north of Carter Lake were superimposed on this plot. Data were available for the years 1980 and 1981. The results of this analysis show that Carter Lake levels are very slow in responding to river stages; however, it was noted that lake levels were sensitive to rainfall runoff from the drainage basin. The plot showed several periods of rapidly increasing river stages with no effect and even perhaps a decrease in lake levels. Periods of heavy rainfall showed a sharp increase in lake level and, consequently, the need to pump water out of the lake by the City of Omaha during three periods in the year 1980. The conclusion that can be drawn from a comparison of these data is that Carter Lake responds slowly to changes in Missouri River stages. A report published in 1960 by the Corps of Engineers entitled Review Report on Navigation and Other Purposes, Carter Lake, Iowa and Nebraska, November 1960 supports this conclusion. It was concluded in that report that there is a silt layer on the bottom of the lake that varies in thickness from 3 to 19 feet. This silt layer consists of a fat clay material that is relatively impervious to seepage and overlays a poorly graded, pervious silty sand layer. Laboratory results from soil samples taken from bore holes in the lake reveal that the material is a fat clay (CH) with a liquid limit of 61 and a

plastic index of 41, which is relatively impervious to seepage flows. The report goes on to state that "the effect of any seepage inflow into the lake is partially offset by other losses and therefore results in only minor increases in lake level."

It was determined that the Storz Freeway, which is under construction and located just north of Carter Lake, will have a minor impact on future lake levels. The land situated north of the freeway does not contribute runoff to Carter Lake because it is situated in a topographical depression.

On the other hand, Eppley Airfield storm runoff is a major contributor to lake levels. The Storage Treatment Overflow Runoff Model (STORM) developed at the Hydrologic Engineering Center (HEC) in Davis, California, was used to model the Carter Lake drainage basin. The model was used to simulate the runoff characteristics of the basin during a 21-year time interval in order to analyze present and future lake level conditions. Runoff is determined by an hourly application of the Soil Conservation Service (SCS) runoff equation allowing for antecedent moisture conditions. Factors used in the program deal with soil infiltration rate, deep percolation rate, detention storage, and soil moisture capacity. Initial values for these factors were obtained from the Soil Survey of Douglas and Sarpy Counties, Nebraska (published by the United States Department of Agriculture SCS). The STORM model was calibrated using lake level readings along with precipitation input for several periods in 1980 and 1981. Generally, maximum infiltration rates ranged from 2 to 4 inches per hour, deep percolation rates were .02 inch per hour, maximum soil moisture storage capacities ranged from 5 to 10 inches, and depression storages were 1 inch.

Groundwater seepage into and out of Carter Lake was determined by using a water balance for the years 1980 and 1981 and the figures are as follows in Table 3.

Table 3
Carter Lake Monthly Groundwater Seepage

Month	Average Seepage (acre-feet)*
Jan	- 110
Feb	- 150
Mar	- 150
Apr	0
May	+ 75
Jun	+ 75
Jul	+ 75
Aug	+ 75
Sep	0
Oct	0
Nov	0
Dec	- 110
TOTAL	- 220

*A plus sign denotes seepage into the lake while a minus sign denotes seepage out of the lake.

The percent impervious ranged from 32.5 percent of the watershed for the present conditions to only 18.9 percent for the future conditions with all of the airport runoff diverted. This reduction of 13.6 percent in impervious area is due to the large percent of impervious areas on the Eppley Airfield grounds from which drainage will be redirected.

Planned Development Impacts

In order to project Carter Lake water levels, a long period of precipitation records was required as input to the STORM program. Precipitation data for the years 1949 through 1969 which was already available on magnetic tape was used for this period of record. The STORM program was run with both the present and two future conditions for this time period. The future conditions consisted of two cases: the first was with all of the airport storm runoff diverted, and the second was with the south half of the airport storm runoff diverted and the north half still contributing to Carter Lake. This will be the case when Eppley Airport completes the first phase of

its planned diversion of runoff from Carter Lake into the Missouri River. The results of the three computer runs were as follows. Under the present conditions, there is an excess volume of runoff into Carter Lake which necessitates periodic pumping from the lake to avoid flooding. With the contribution of the entire airport drainage area to Carter Lake eliminated, a low water problem would exist which would necessitate pumping water in from an outside source, most likely the Missouri River. Under this condition, it would also be necessary to make emergency provisions to be able to pump water out of the lake in the event of a large runoff event. With only the southern half of the airport area eliminated from contributing to Carter Lake, a minor high water problem would exist necessitating pumping from Carter Lake on a more limited basis than with present conditions.

Evaluation of Methodology

The analysis presented here is based on the calibration of the STORM program to hydrologic records for the years 1980 and 1981. These years were selected primarily because of data availability and the limited pumping requirements. In the calibration studies, all leftover quantities of water not measured were assumed to be representative of the seepage factor. This factor was then used for the model simulation for the period of record from 1949 to 1969.

When, however, data from the years 1983 and 1984 were examined, it was seen that a much larger amount of apparent seepage into the lake had occurred. It can logically be assumed from a water budget developed for each of these years that much of the water pumped out of Carter Lake by the City of Omaha to control basement flooding was seepage into the lake from an apparent high groundwater table. The exact cause of the high groundwater table is not known, but it is evident from the Carter Lake pumping records and lake level records that pumping continued during periods of low precipitation without

lowering the lake level significantly. Under this condition, even if the airport storm runoff were diverted, pumping would still be required to maintain the lake at desirable levels.

Conclusion

It has been shown that either a high water or a low water problem could exist after the airport drainage area is eliminated as a contributor to Carter Lake, depending on the data used in the analysis. These two seemingly conflicting results are both valid. The differences arises because the data used in each case were obtained from years which had different groundwater conditions. The lack of sufficient data to carry out a hydrologic analysis for other years prohibits any conclusions as to which groundwater situation is most likely to occur. Therefore, the final conclusion as to what measures will be necessary to control future water levels in Carter Lake is that the proposed pumping system should be able to both bring water into Carter Lake as well as take water out of the lake.