PRELIMINARY DESIGN REPORT

CARTER LAKE

WATER LEVEL CONTROL

January 1997

THE SCHEMMER ASSOCIATES INC.

ARCHITECTS · ENGINEERS · PLANNERS

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INTRODUCTION

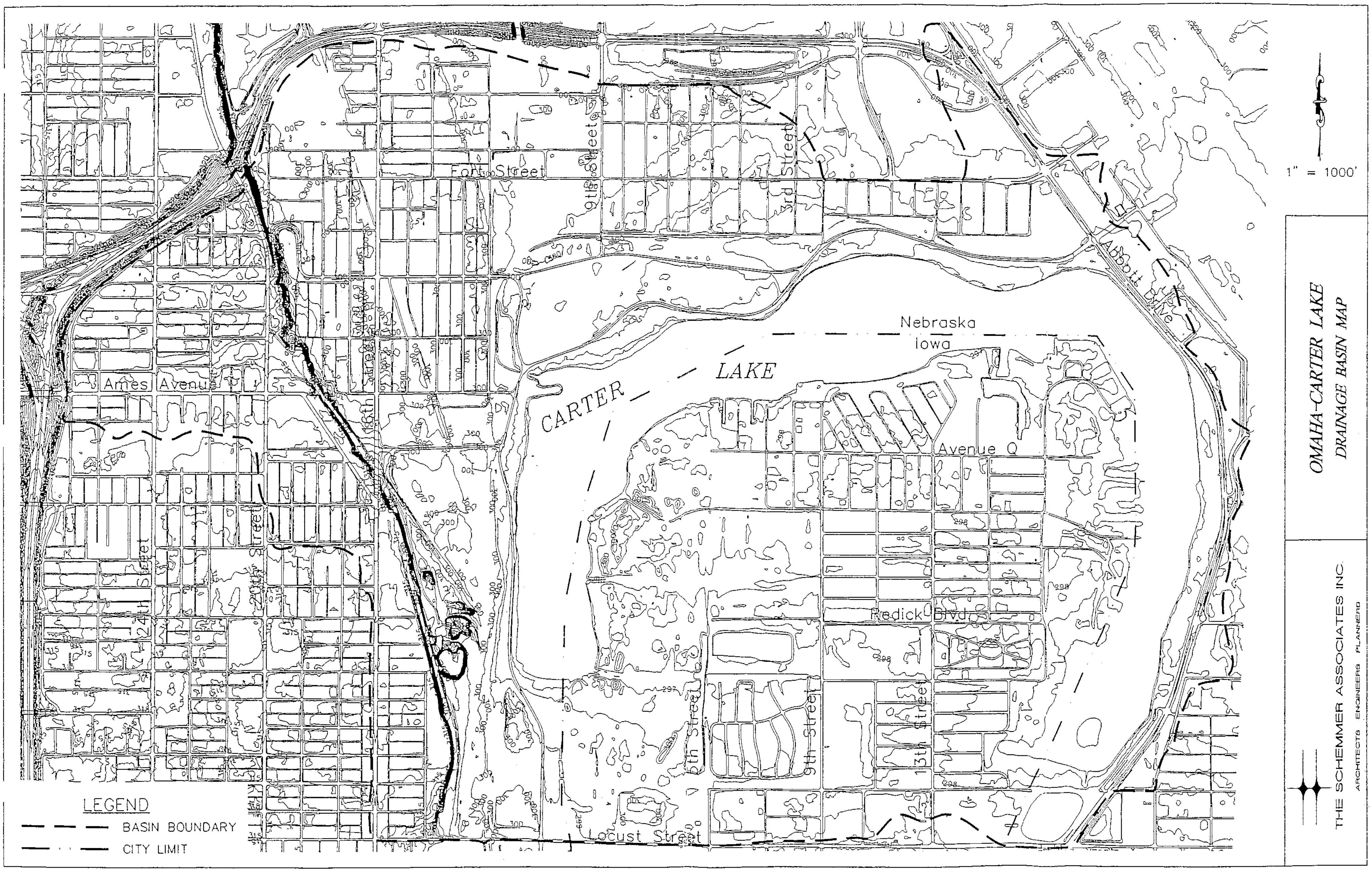
Carter Lake was formed when the ox bow in the Missouri River was isolated by channel changes in the 1880s. Since the creation of the lake, numerous activities have occurred that impact the lake. Most of this activity directly affected the water surface elevation. Primarily, city expansion increased runoff to the lake and levee construction eventually eliminated high river water from filling the lake. The water level and water depth have been continuously monitored by various groups depending on their concerns. Low water surface elevation and shallow depth restricts the lake's use for boating and fishing. Conversely, high water surface elevation can cause localized flooding and resultant increases in the adjacent ground water elevation. This ultimately generates water damage to nearby residences and businesses. Due to these concerns, the City of Omaha and the City of Carter Lake requested a study of the existing systems which ineffectively maintain water level. And further, it was requested that recommendations be made as to improvements that would be necessary to cost-effectively regulate the lake level. This study included both the filling and the withdrawal of water from the lake.

DRAINAGE BASINS AND EXISTING SYSTEMS

Carter Lake receives stormwater runoff from several locations which include both underground storm sewers and overland contributing areas. Research of existing storm sewer construction drawings, City of Omaha quarter section storm sewer inventory maps, available aerial mapping, and field reconnaissance were performed in an effort to estimate the limits of the contributing drainage area. This area is shown on the enclosed Drainage Basin Map and totals approximately 2,230 acres.

There are several existing storm sewers that can be found throughout the drainage basin. Both the North Interceptor and the Minne Lusa storm sewers originate in areas further upstream to the north and west and continue south beyond this drainage basin. Upon review of previously performed model data for each system and from conversations with the City of Omaha Sewer Maintenance Division, it was determined that both of these storm sewer systems will be at or beyond full capacity prior to entering the Carter Lake drainage basin and will be virtually unable to intercept or transport any additional runoff from this basin to areas to the south. This is realized quite easily since storm sewer pipe slopes are very flat (less than one-tenth of a percent).

Several storm sewer systems exist on the drainage basin perimeter that transport runoff away and help define the basin that contributes runoff to Carter Lake. One such system exists in an industrial park at the vicinity of Airport Drive and Storz Expressway. This system originates at Fort Street and conveys runoff to the north. Pipe sizes vary in size from 24-inch at Fort Street to 60-inch near Storz Expressway. The capacity of this system was not analyzed in great detail. However, considering this system's pipe sizes, slopes, and the direction of overflow, it was assumed to be generally capable of conveying runoff from its contributing area to locations outside of our area of interest.


OMAHA-CARTER LAKE
DRAINAGE BASIN MAP
THE SCHEMMER ASSOCIATES INC.
ARCHITECTS ENGINEERS PLANNERS
1" = 1000'
LEGEND
BASIN BOUNDARY
CITY LIMIT
CARTER LAKE
Nebraska
Iowa
Abbott Drive
Avenue Q
Redick Blvd.
Locust Street
Fort Street
Ames Avenue
3rd Street
9th Street
5th Street
13th Street
24th Street
20th Street

Another existing storm sewer system that conveys storm runoff and helps define the Carter Lake drainage basin limits is the system associated with the Storz Expressway. The Final Design Narrative Report for Storz Expressway Stormwater Drainage System (August 1981) and as-built construction drawings were both reviewed in an effort to delineate the majority of the north basin boundary. The systems designed as part of that project were intended to accommodate 10-year and 50-year runoff volumes. If larger storms were to be encountered, it appears that, due to topographic conditions and overflow paths, the Carter Lake drainage basin will not be significantly impacted.

Regarding storm sewer systems on the east side of the drainage basin, several systems exist along Abbott Drive that intercept runoff and convey it to Carter Lake. Only areas that directly contribute to these systems in Abbott Drive were considered. Other systems providing for Airport runoff have been subsequently constructed to transport runoff elsewhere.

From discussions with City of Omaha Sewer Maintenance Division personnel, it was discovered that there are plans to design and construct a future storm sewer system or systems that will more effectively drain storm runoff from the area northwest of Carter Lake. This area is generally bounded by 13th and 18th Streets on the west and east, Ames Avenue to the south, and Storz Expressway to the north. This system would drain an area that generally flows over land to Carter Lake now, but only in a manner that will be more efficient. Construction of such a system will help resolve some existing local flooding problems. It is anticipated that detention facilities will be used in a manner to help improve storm water quality as well as to minimize sharply peaked hydrographs. Although these facilities may influence the rate at which these areas drain to Carter Lake, the overall total volume of runoff will likely be unchanged.

HYDROLOGIC ANALYSIS

Hydrologic calculations were performed so that storm runoff volumes that are tributary to Carter Lake could be estimated for various rainfall events. The runoff amounts that will result from precipitation are heavily dependant upon the amount of impervious surfaces or land use types that are encountered. Therefore, to achieve a thorough runoff estimate, anticipated future land uses were utilized for these calculations.

Current zoning information was obtained for both the City of Omaha and the City of Carter Lake. For the City of Omaha, the future land use plan that is proposed as part of their "draft" master plan was used since it is the most current. Only minor differences, in the area of interest, can be seen when compared to the "present" land use plan. Both plans were prepared by the City Planning Department. This land use information has been compiled and is shown on the enclosed Land Use Map. This figure was developed only to identify future hydrologic parameters and is not intended to be considered as a land use planning document. The following table presents a summary of the land use tabulations in the form of a percentage of the total contributing drainage area.

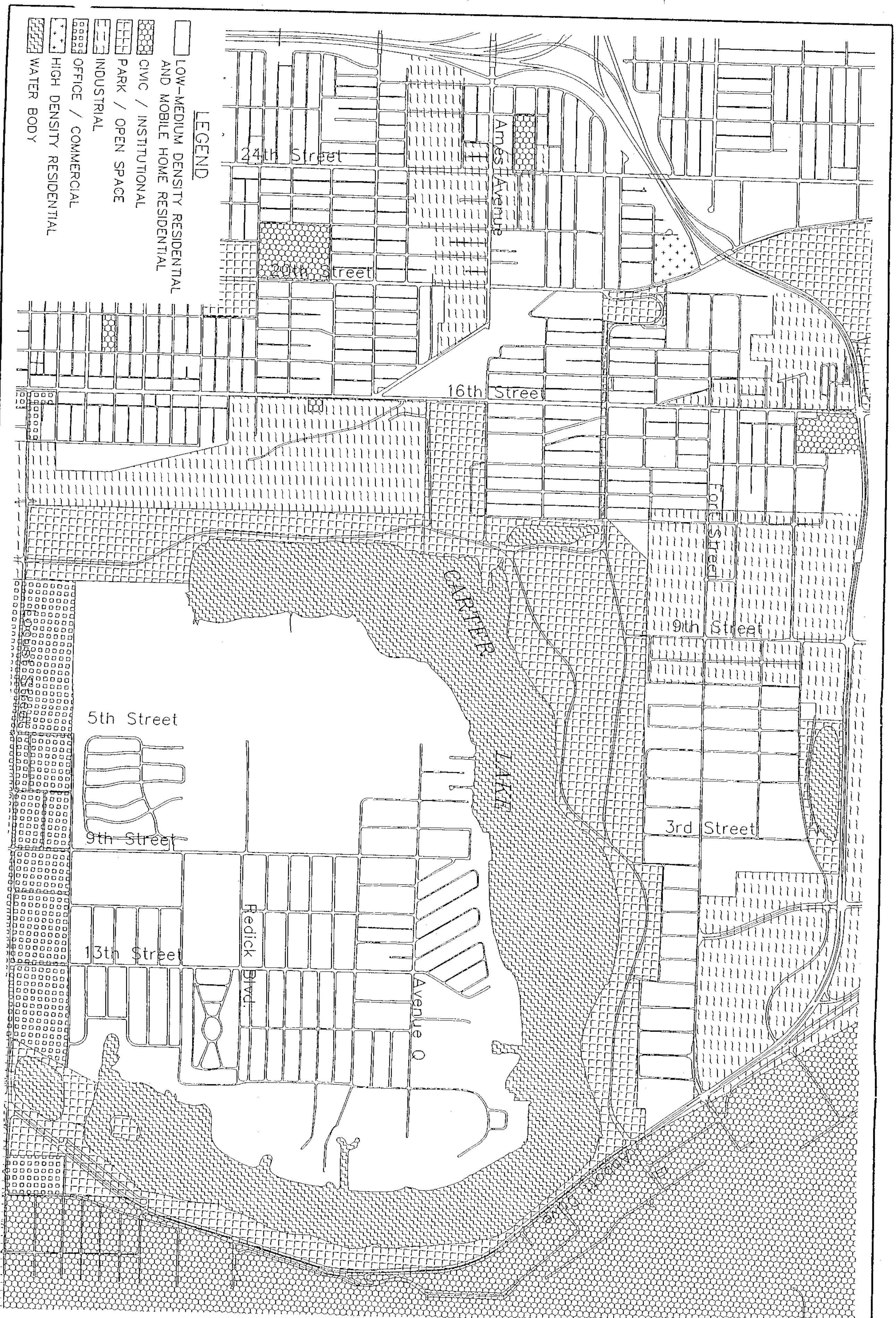
LAND USE CATEGORY	PERCENT
Low-Medium Density Residential	49.6
Mobile Home Residential	2.9
High Density Residential	0.2
Office/Commercial	3.2
Industrial	12.9
Civic/Institutional	2.7
Park/Open Space	13.5
Water Bodies and Marsh Areas	15.0

For purposes of hydrologic calculations, low-to-medium density residential and mobile home residential areas were combined. Also, industrial and civic/institutional areas were combined.

This was done to simplify calculations since they are very similar hydrologically and have almost identical percent of impervious surfaces associated with them.

Upon review of the previously mentioned design report for the Storz Expressway Stormwater Drainage System, it was noticed that a somewhat unique hydrologic method was used that may be difficult to recreate. Also, the use of the rational method would be conservative and unreasonable for drainage basin of this magnitude (3.5 square miles). Therefore, the steering committee supported the consultant's recommendation of the use of a more universally accepted synthetic hydrograph method such as the Soil Conservation Service method. Therefore, the SCS Type II rainfall distribution for a 24-hour storm was applied to the basin under fully developed conditions to arrive at runoff volume estimates.

Based upon review of the Soil Conservation Service Soil Survey for the region, most of the soils consist of silty and sandy loams or clays. For purposes of runoff calculations, the soil hydrologic grouping or classification was considered to be that of a "C" group throughout the basin. The composite curve number used for rainfall to runoff correlations, reflecting future land uses and soils information, was an 85.5.



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OMAHA-CARTER LAKE

LAND USE MAP

1" = 1000'

Runoff and corresponding volumes were calculated for the 10-, 25-, 50- and 100-year storm frequencies. The results of the hydrologic analysis is shown on the table below.

STORM FREQUENCY	RAINFALL (inches)	RUNOFF (inches)	RUNOFF VOLUME (acre-feet)
10-year	4.70	3.14	582.86
25-year	5.40	3.79	703.52
50-year	6.10	4.45	826.03
100-year	6.70	5.02	931.84

The timing of when storm water runoff from contributing areas reach Carter Lake will clearly have an impact upon the rate at which rises in the lake water surface occur. This time is very difficult to accurately calculate due to the drainage basin conditions. Much of the runoff that occurs in this basin is in the form of overflow from existing storm sewer systems or overflow from depression areas. Most other contributing areas are very flat. Nevertheless, using conventional calculation methods, the time of concentration for the Carter Lake drainage basin is estimated to be approximately 58 minutes, not including travel time to the pump station force main from the lake.

CLIMATOLOGICAL ANALYSIS

Although the SCS 24-hour storm is a widely accepted hydrologic method for use with storm drainage design, it is quite conceivable that a series of smaller events that occur within a time frame of 2 to 4 days could create a severe storm drainage condition. This type of "period of rainfall" design philosophy is worthy of investigation, especially with designs pertaining to detention or reservoir storage.

Fortunately for this project, a rainfall gaging station is very close (Eppley Airfield) and provides a wealth of representative data. The gaging station at Eppley Airfield has been in operation since 1948 and, therefore, provides over 48 years of rainfall data. A listing of daily rainfall amounts was obtained for the full period of record from the High Plains Climate Center at the University of Nebraska in Lincoln. This data was first sorted to rank this daily rainfall from "largest to smallest". The enclosed table entitled "Daily Precipitation Amounts" shows the "top twenty" rainfall values.

In an effort to find a series of four days that accumulatively had the most precipitation, the individual daily highs were first evaluated in that they could provide a good "anchor" with other surrounding rainfall events. Secondly, the daily rainfall data was filtered to find all days in which "greater than one inch" of rainfall occurred. This data was then scanned for days that fell within a four calendar day group and with the most rainfall. The enclosed table entitled "Four Day Precipitation Amounts" summarizes the findings of this climatological analysis. Also shown in the table is an estimate of the corresponding runoff amounts for each rainfall period as well as an approximate recurrence interval for each of the four-day groups. This information is neither hydrologically or statistically precise but it does provide a very good estimate for comparison purposes. This four day group size seemed to be a reasonable size since the objective was to find a worst-case scenario. General review of the data showed that if the group were expanded to five days, it would add roughly one inch of rainfall to the total. After five days, the average daily rainfall declines more rapidly. To confirm that an optimum time period (four days) had been found, the amount of rainfall required to cause a lake rise during continual

Daily Precipitation Amounts

Eppley Airfield - Omaha, Nebraska

Ranking	Month	Day	Year	T-High F	T-Low F	Precipitation (inches)	Snow (inches)
1	9	7	1965	78	62	6.24	0
2	5	26	1987	71	61	4.16	0
3	6	22	1994	85	68	4.07	0
4	9	25	1973	79	60	3.53	0
5	5	30	1961	69	55	3.31	0
6	8	2	1959	90	67	3.27	0
7	7	29	1948	89	68	3.22	0
8	10	16	1968	75	50	3.09	0
9	5	20	1982	74	60	3.07	0
10	5	2	1959	83	61	2.99	0
11	10	10	1961	70	57	2.85	0
12	7	12	1950	79	61	2.82	0
13	6	13	1983	77	59	2.79	0
14	8	31	1969	70	63	2.77	0
15	8	22	1959	93	70	2.75	0
16	9	8	1989	71	56	2.71	0
17	10	11	1986	57	38	2.7	0
18	7	9	1987	88	64	2.69	0
19	5	10	1971	73	58	2.66	0
20	5	11	1972	78	67	2.64	0

pumping was calculated. If the drainage rate of the lake were 9,000 gallons per minute (gpm), it would require daily rainfalls of 0.6 inches or more to keep up (cause additional lake rise). This is when considering a high ground saturation condition (Antecedent Moisture Condition-AMC-3). For a normal pre-saturation condition (AMC-2), it would take over an inch of daily precipitation to equate to 9,000 gpm over a 24-hour period. And with higher pumping rates, it would take an even greater daily precipitation. This basically confirmed the estimate that the four day grouping would provide an good time period for purposes of this analysis.

Four Day Precipitation Amounts

Eppley Airfield - Omaha, Nebraska

Group Ranking	Month	Day	Year	Precipitation Daily (inches)	Precipitation 4 Day Total (inches)	Approximate Runoff (inches)	Approximate Recurrence Interval
1	9	6	1965	0.84	8.04	5.87	48 yr.
	9	7	1965	6.24			
	9	8	1965	0.96			
	9	9	1965	0.13			
2	7	21	1993	0.64	5.93	4.16	24 yr.
	7	22	1993	2.54			
	7	23	1993	0.26			
	7	24	1993	2.49			
3	9	23	1973	0.68	5.69	3.88	16 yr.
	9	24	1973	0.38			
	9	25	1973	3.53			
	9	26	1973	1.10			
4	7	8	1987	0.66	5.57	3.75	12 yr.
	7	9	1987	2.69			
	7	10	1987	1.31			
	7	11	1987	0.91			
5	8	28	1993	1.17	5.00	3.34	9.6 yr.
	8	29	1993	2.05			
	8	30	1993	1.78			
6	5	2	1959	2.99	4.95	3.31	8 yr.
	5	3	1959	0.01			
	5	4	1959	1.56			
	5	5	1959	0.39			
7	5	19	1982	0.51	4.92	3.29	6.9 yr.
	5	20	1982	3.07			
	5	21	1982	1.34			
8	5	24	1987	0.31	4.90	3.27	6 yr.
	5	25	1987	0.36			
	5	26	1987	4.16			
	5	27	1987	0.07			
9	8	26	1957	0.24	4.58	3.06	5.3 yr.
	8	27	1957	0.83			
	8	28	1957	2.41			
	8	29	1957	1.10			
10	7	12	1950	2.82	4.57	3.05	4.8 yr.
	7	15	1950	1.72			

MISSOURI RIVER vs. CARTER LAKE

A. RIVER ELEVATION vs. LAKE ELEVATION

Over time, the question has been posed as to whether there is a correlation or connection between the elevations of the Missouri River and the elevation of Carter Lake. Hydrogeologic conditions are very complex and difficult to analyze without a significant amount of data and study. Even with a large amount of hydrogeologic data, it would be difficult to reach accurate conclusions. Nevertheless, several groups have attempted to investigate this.

One such group or agency was the U. S. Army Corps of Engineers. A Carter Lake groundwater study was performed by the Corps in 1988 which evaluated potential underground connections between the river and the lake. Correlations between the river and lake with adjacent groundwater levels varied depending on the area of interest. The study concluded that Carter Lake water surface elevations are more dependent on local precipitation and evaporation rather than the Missouri River stage or level.

The City of Omaha has also been monitoring groundwater, lake, and river elevations. Based on a brief review of a portion of this piezometric data, a direct connection between the lake and the river was not supported. However, there were periods of record where some correlations occurred in the data. This could mean that there is a very weak hydrogeologic connection (such as through thin lenses or strata near the lake bottom) or simply that it rained that day and subsequent rises occurred at both locations. For the majority of the time, however, there is not a correlation between the data. These findings support the theory that there is not a hydrogeologic connection of any significance. The piezometric data tabulated could be used to a greater extent, when combined with additional data, if an effort were pursued in the future by the City of Carter Lake or others to better understand or resolve localized groundwater problems. But, such an effort is beyond the scope of this study.

B. BASEMENT FLOODING

From discussions with City of Carter Lake representatives and their descriptions of correlations between rainfall events and basement flooding, it appears that flooding of basements in part of the City is more likely caused by localized hydrogeologic conditions rather than by rises in the Missouri River or Carter Lake water surfaces. There may be previous soil lenses that are trapped between less pervious or impermeable soils that transport infiltration from runoff to a few localized problem areas. In order to formulate possible solutions to these problems, a relatively comprehensive and detailed hydrogeologic analysis that specifically targets those problem areas would need to be performed.

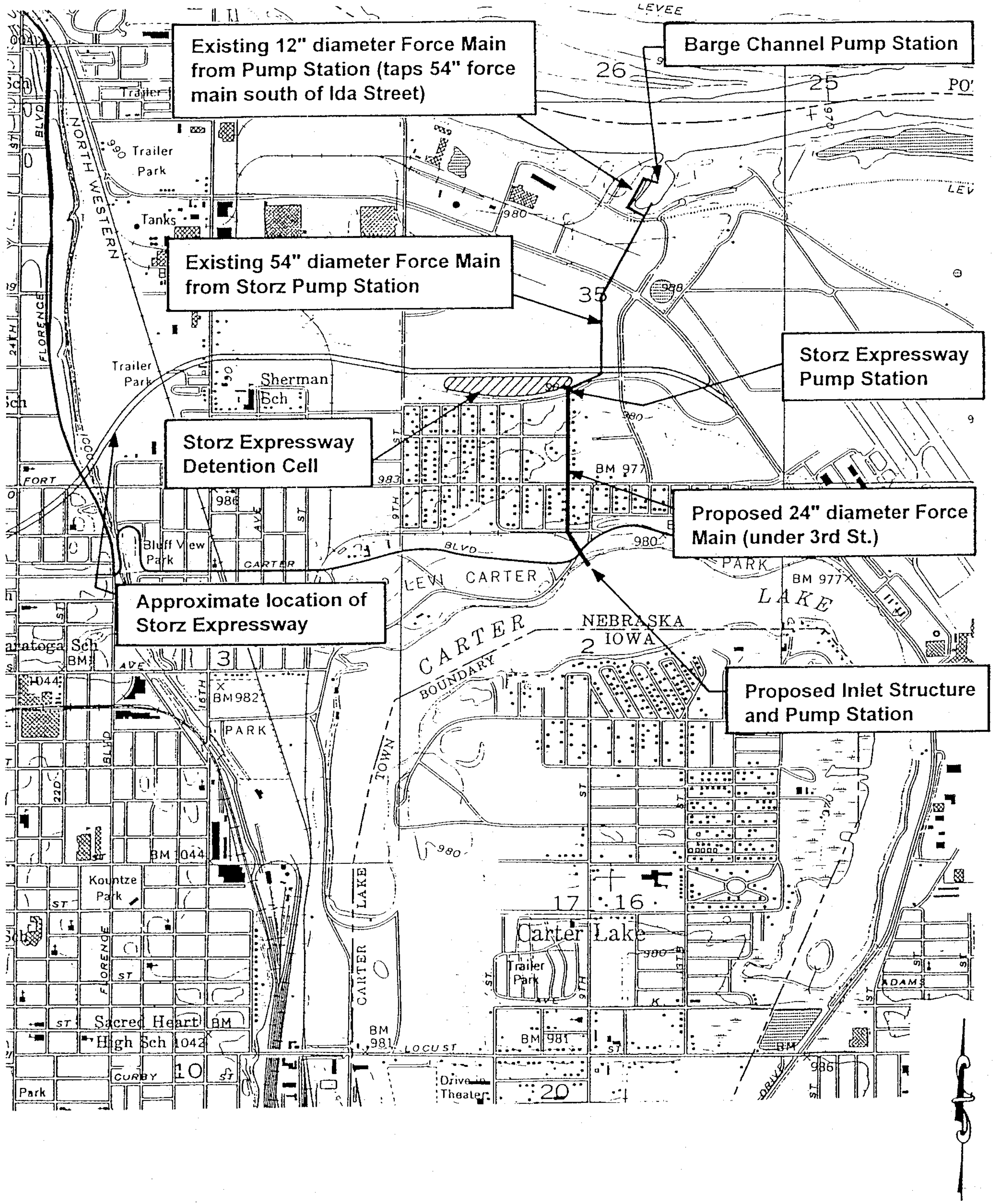
DESIGN DISCUSSION

WATER SURFACE ELEVATION CRITERIA

A meeting to discuss the lake elevation study was held on September 5, 1996 at Omaha Douglas Civic Center with representatives from the City of Omaha, the City of Carter Lake and the consultant. As a result of the meeting, it was determined that the desired lake elevation should be 970.3 feet (mean sea level) with a variance between 969.8 and 970.8 feet in elevation. The group's experience had been that water surface elevations lower than 969.8 feet have been found to restrict recreational usage of the lake and to impact the lake ecosystem. An elevation of 971.0 feet was considered as a preferred maximum. Water surface elevations higher than 971.0 for an extended period of time cause considerable water damage to adjacent residences and businesses. The surface area of Carter Lake was estimated to be 323 acres. Assuming a negligible increase in water surface area (a conservative assumption) as the level rises, each inch of increase in water elevation equates to approximately 1.16 million cubic feet of water.

EXISTING SYSTEMS

The City of Omaha currently has two systems in place for maintaining water surface elevations for the lake within desired tolerances. For purposes of this study, the existing 18-inch pipe and pumping station that directs water from Carter Lake to the Storz Expressway Pump Station force main and a pump structure located in the Missouri River Barge Channel that directs river water back to the Storz Expressway Pump Station were reviewed. The same submersible pump is used interchangeably at each location. The first system involved a supply system using drain pipes and a pump structure designed to supply water to Carter Lake when the water surface elevation was lower than desirable. Water could be supplied from the Missouri River from a structure in the Barge Channel north of the Pump Station. The pumping station there was equipped with a 12" force main routed to the 54" force main from the Storz Pump Station. Water is then allowed to drain by gravity from the 12-inch connection back to the Pump Station through the 54-inch line then on through to the lake via an 18" PVC pipe. The following Facilities Location Map shows the drainage facilities described.



SCALE: 1" = 2000'

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FACILITIES LOCATION MAP

OMAHA - CARTER LAKE

The capacity of the interchangeable pump when used at the Barge Channel is approximately 2,100 gpm. Its capacity exceeds the average net evaporation loss (4.0 inches) for the worst typical month. This equates to 785 gpm. The following table, Average Monthly Climatological Data, shows the average net evaporation losses for each month of the year.

Average Monthly Climatological Data

MONTH	PRECIPITATION (Inches)	EVAPORATION (Inches)	NET EVAPORATION LOSS (Inches)
January	0.7	0.7	0
February	0.9	0.9	0
March	1.4	1.6	0.2
April	2.6	3.1	0.5
May	3.6	4.6	1.0
June	4.6	5.9	1.3
July	3.7	7.7	4.0
August	3.4	6.5	3.1
September	3.0	4.9	1.9
October	2.0	3.5	1.5
November	1.2	1.7	0.5
December	0.9	0.9	0

Data from Corps of Engineers, "Review Report on Navigation and Other Purposes - Carter Lake, Iowa and Nebraska," November 1960.

The 18" PVC supply pipe used for Carter Lake was subsequently fitted with a pump structure at the lake shore. The pump at the supply station near the river was removed and installed to withdraw water from the lake to the Storz Pump Station force main and then on to the Barge Channel through the 54" line. The interchangeable pump does not have the capacity to create significant water surface elevation changes. When used on the supply end, it only needs to match evaporation. But, when used on the withdrawal end, storm flow is too large. Increasing delivered capacity is precluded by the existing construction. The 18" PVC pipe was designed as a "gravity line" with only low internal pressure capabilities. Consequently, if an attempt were made to increase capacity for withdrawal, a pump size increase and its associated pressure increase would potentially damage the existing pipe and joints. Major leaks would almost certainly develop with time if not immediately.

LEVEL CONTROL ANALYSES

A. Objectives

The goal of the study was to evaluate the feasibility of optimizing the performance of the level control systems while considering the vast number of variables and construction limitations. Pumping water from the lake to control high water levels and pumping water into the lake to maintain minimum water levels have been discussed in this study. Recent soil borings indicate that groundwater depths vary from 6' to 8' below present grade along the route from Carter Lake to the Storz Expressway Pump Station. With high groundwater, construction cost and constructibility serve to diminish viability of any proposed plan involving placement of a pipe below or near the groundwater level. The objective to lower high lake levels will be discussed first. For removing water from the lake, a ten to fourteen day period was recommended as the practical limit for a time interval by both cities to return the surface elevation to acceptable levels. With this time period, it was understood by both cities that some flood damages would likely occur due to corresponding rises of the Carter Lake water surface.

B. Controlling High Lake Levels

1. Gravity Lake Drain

The concept of a gravity drain line from Carter Lake to the Storz Expressway Pump Station was reviewed in depth at an earlier phase of this study. Based on withdrawal volume requirements and minimum slopes, a 36-inch diameter pipe buried to depths up to 20 feet deep was required. Although this line could provide flow minimums to meet time objectives, construction difficulties as well as economic and operational issues at the Pump Station eliminated this as a viable option. Construction difficulties included the high water table, excessive trench depth, close proximity of adjacent water and storm pipes above the 36-inch-diameter pipe, and requirement to maintain access to nearby residences. The deep entrance of the 36-inch-diameter pipe at the Pump Station placed it below normal operational water levels in the wet well. Entrance into the detention cell was not possible. Measures would be required to prevent water from backing up in the 36-inch-diameter pipe and flowing to the lake. The deep pipe entrance would also require modification of the existing pumps, likely including the addition of an additional moderately sized pump and adjusting cycle times to allow the system to operate as intended.

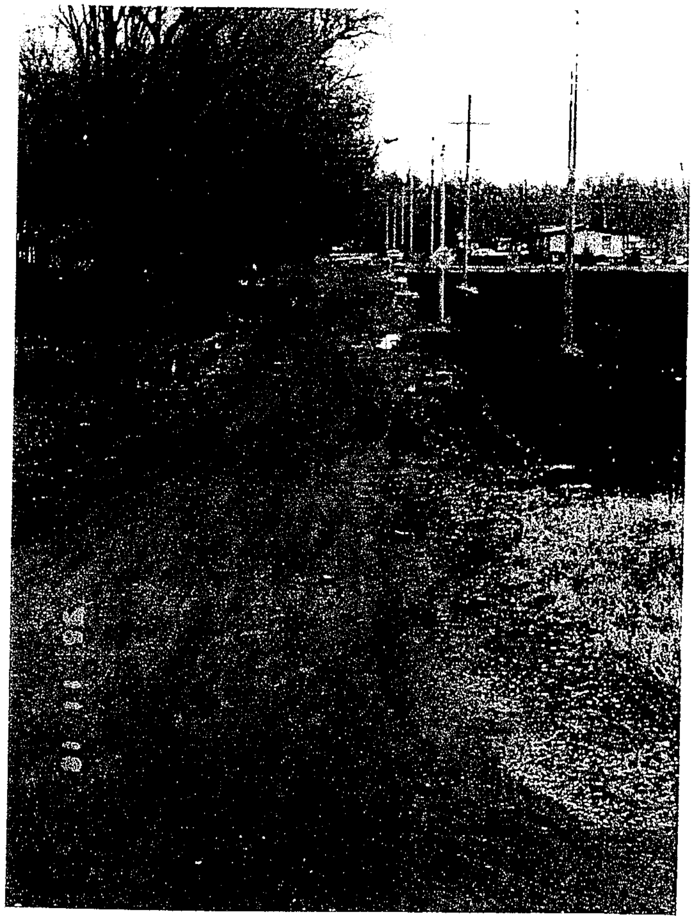
2. Force Main Drainage

An intake structure with a pump at Carter Lake and a new force main tapped into the Storz Expressway Pump Station force main provide a viable solution for several reasons. A new force main size would be of a smaller diameter than a gravity line and could be installed at much shallower depths, thus significantly reducing construction costs.

A new 18-inch and a 24-inch diameter pipe were compared as shown in the following table.

DESIGN PARAMETER	PIPE DIAMETER			
	18 Inch		24 Inch	
Pipe flow, gallons per minute	9,000	12,000	9,000	12,000
Total Dynamic Head, feet	113	172	54	67
Internal Pipe Pressure, pounds per square inch	49	74	23	29
Minimum Pump Size, horsepower	320	650	150	250

As shown above, the use of a 24 inch pipe performs much better and will impose less pumping requirements than that of a 18 inch pipe. This converts directly to initial construction cost as well as long term operational cost savings.



View looking south along 3rd Street from Fort Street.
(Proposed force main at right edge of street.)

Storz Expressway Detention Cell - looking west
at the inlet structure for the pump station wet well.

A comparison of the time interval necessary to bring the Carter Lake elevation to within acceptable levels (drain time) and the corresponding lake level rise was performed for both 9,000 and 12,000 gpm pumping rates. This comparison is summarized in the following table.

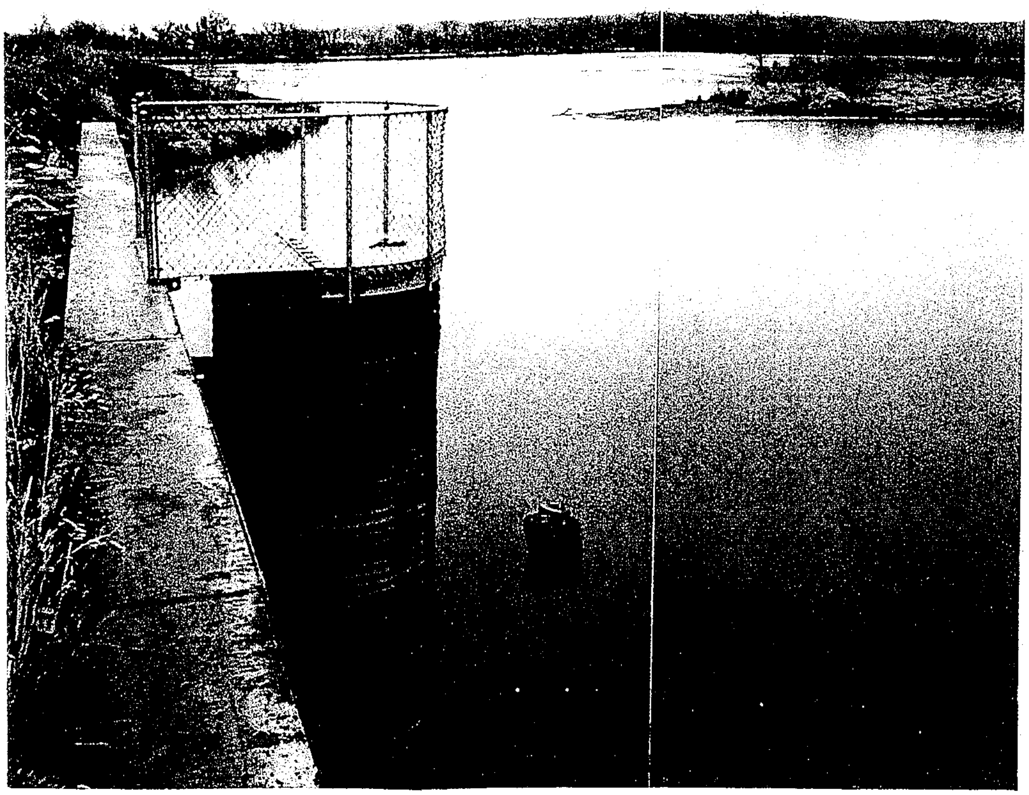
STORM FREQUENCY	TOTAL RUNOFF VOLUME (ac.-ft.)	LAKE RISE (ft.)		DRAIN TIME (days)	
		9,000 gpm	12,000 gpm	9,000 gpm	12,000 gpm
10-year	582.9	1.68	1.63	10.6	7.9
25-year	703.5	2.05	2.01	13.6	10.2
50-year	826.0	2.43	2.39	16.7	12.5
100-year	931.8	2.76	2.71	19.4	14.5
Historical (4-day)	1,089.6	3.24	3.20	23.3	17.5

The 9,000 gpm rate would require a minimum sized pump of 150 hp whereas the 12,000 rate would require a 250 hp pump. These pump sizes as well as the drain times presented above are with the use of a 24-inch-diameter pipe.

While finalizing the study, the question was raised regarding the potential use of the existing 18 inch gravity line (now force main) in tandem with a new 21 inch force main. By using the existing 18 inch line in tandem, it was hoped that the proposed 24 inch force main could be reduced to a 21 inch diameter line. This would of course permit savings in material cost and assign use to the existing 18 inch line. Assuming the 18 inch gravity line was acceptable to use as a pressure line on a long term basis, a cost comparison was developed. Downsizing the proposed force main from 24 inch to 21 inch creates a resultant increase in operating head for the pumps. In this instance, the increase is 13 feet of head. The head increase results in additional horsepower requirements of 38.6 horsepower per pump or an added cost of approximately $44,000. The resultant cost savings in pipe is estimated at $12/LF or approximately $30,000. If a 21 inch line were used and the 18 inch line should fail at a later date, each pump would require an additional 38 horsepower to maintain 9,000 gpm for the system. Therefore, use of the 24 inch force main is more prudent and cost effective.

A 24-inch-diameter pipe and a pump with a design flow of 9,000 gpm could reduce the lake water surface elevation nearly one and one-half inches per day. An inlet structure will be required to prevent debris from entering the withdrawal point. The outlet end will be tapped into the Storz force main with appropriate valving.

View looking southwest toward the proposed wet well location at the edge of Carter Lake.



View looking northeast at the Barge Channel pump structure. Note the narrow channel opening to the Missouri River (river water elevation approximately 977' msl).

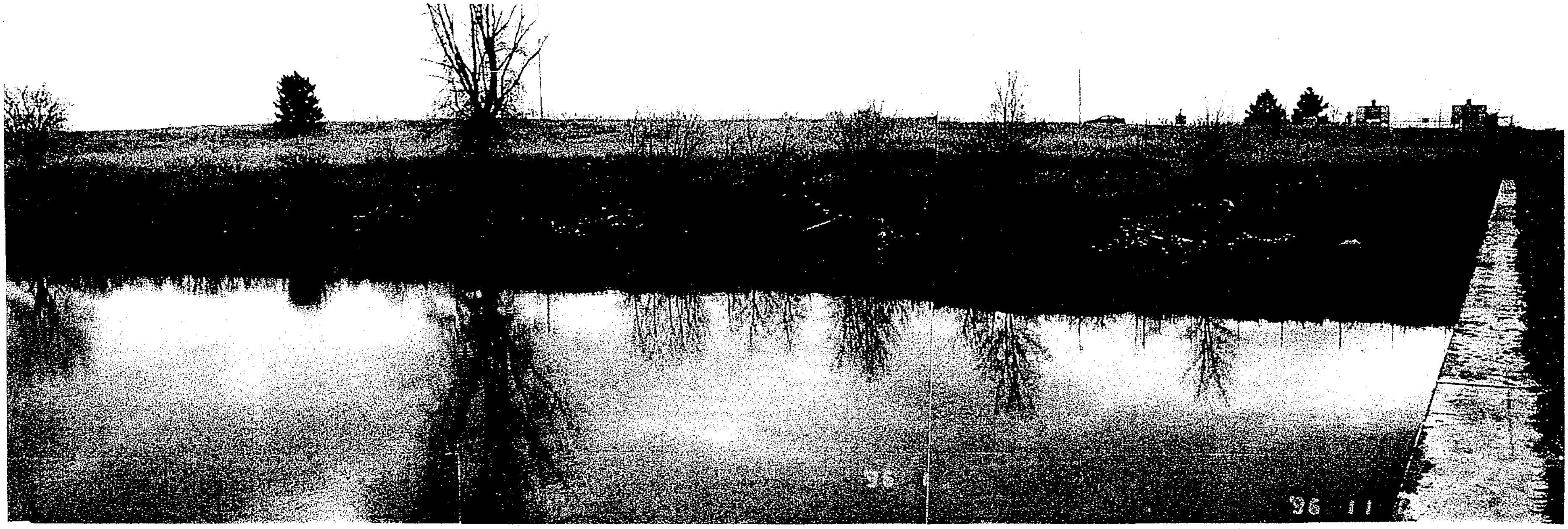
Several utility lines will be crossed in the process of constructing the drain line and will have an economic impact on the project by cautious construction or by relocation. Metropolitan Utilities District 3-inch gas and 12-inch water lines will be crossed at Third and Fort Street. A 14-inch force main will be crossed at Third and Jaynes Street. Residential gas and water service lines will also be crossed. The Storz Pump Station water supply lines will be crossed at 3rd and Hartmann Avenue.

C. Low Water Level Control

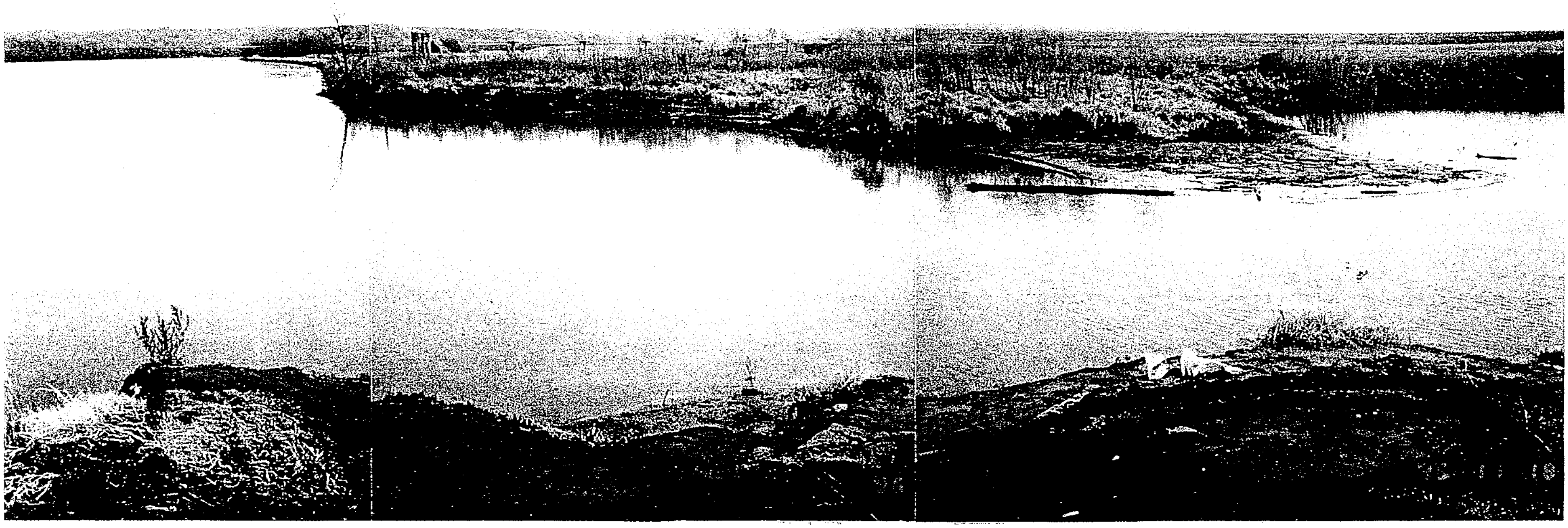
Conversely, as dry years occur, a plan to add water to Carter Lake is needed to maintain the desirable minimum lake water surface elevation. Stormwater runoff collected at the Storz Expressway Detention Cell and river water pumped from the Barge Channel, discussed earlier, are the current sources for providing water to the lake. Stormwater runoff is an economical source of water. However, during dry years this source cannot be relied upon to provide the necessary volume of water. The Missouri River is relatively close and can provide the water needed. However, the times when the lake needs water often will coincide with low river flows. The minimum water surface elevation of the river at the Barge Channel as provided by the Corps of Engineers (COE) is 962.7' mean sea level. With a water surface elevation of roughly 970' mean sea level at the lake, it is clear that pumping would be required.

D. Barge Channel Pump Station

The existing interchangeable pump and structure at the Barge Channel appear to be capable of providing the necessary volume of water to maintain the lake level, once necessary modifications are made to enable the system to operate as intended. Currently, the pump station intake is completely covered by river silt. In order to operate the pumping station, channel dredging would be required. The natural ground elevation in the Barge Channel is approximately 973' mean sea level. This is more than ten feet above minimum river levels. The water intake structure must be modified to protect it against sediment in the pump pit.



View looking toward the south end of the Barge Channel.
The headwall and 54" force main from Storz Expressway is at the center of the photograph.



View looking east toward the entrance of the Barge Channel.
Note the narrow entrance to the channel as well as it appearing quite shallow.

Consideration should be given to installation of a sediment trap in the delivery system to reduce the amount of sediment sent to the lake. A small bermed area or concrete trough with a weir structure could be constructed south of Ida Street to perform this function.

RECOMMENDATIONS AND CONCLUSIONS

A. High Water Level Control

For removing water from the lake, it is recommended that a pump with a 9,000 gallon per minute (gpm) design flow in a new structure at the lake coupled with a 24" diameter pipe be installed and tapped into the Storz Expressway Pump Station force main (54 inch). Construction cost of this proposal excluding design fees, land acquisition or easements is approximately $626,900. The preliminary design and cost estimate were for a simplex pump system. Duplex systems should also be considered for the final design phase of this project. It is anticipated that construction cost would decrease to approximately $567,000. A detailed cost estimate which reflects the above values can be seen in the appendix of this report.

Another option the City has requested be evaluated is for the continued use of the existing 2,100 gpm pump at Carter Lake into the 18" PVC line. Utilization of this system would reduce the proposed design system from 9,000 gpm to 6,900 gpm. A duplex system to pump 6,900 gpm through a 24" pipe and then directly (with a check valve) through the existing 54" pipe to the Barge Channel would cost approximately $550,400.

Construction cost of these proposals does not include design fees, land acquisition or easements. Two concerns need to be addressed prior to recommendation of either of these options. First, the 2,100 gpm pressurizes the existing 18" line which was designed as a "gravity line" without pressure. Pressure in the 18" line will in time cause joint leaks with subsequent loss of subgrade support and, potentially, pipe failure. Secondly, for pumping to the Barge Channel, the proposed system operation could not begin until the Storz Expressway Pump Station was not operating due to back pressure and necessary protective check valves. It is anticipated that such a situation would cause an additional (assumed 24-hour) delay to the drain times previously presented.

B. Low Water Level Control

With the modifications discussed previously, the Barge Channel pumping station "theoretically" can serve to supply river water to the lake. But, since the Barge Channel is situated on the outside of a bend in the Missouri River, sediment accumulation at the pump structure is a major problem and will continue to be so. Additional studies and consultation with the Corps of Engineers are required to make the pump station "realistically" functional. At present, the pump station is "useless". As a minimum, significant dredging must take place in order to consider using the existing system.

From recent examination of the Barge Channel, it appears that it has not been used for barge traffic at all.

Extension of a new intake line from the Missouri River to the pump station would be the only way to assure quick and reliable operation. A new intake structure such as this would be very costly. This is due to the requirements that the intake must be able to operate:

1. Operate at river levels at least ten feet below normal levels.
2. Be constructed in a way to minimize blockage of the intake by the shifting river bottom.

Operation at low river levels requires that the intake point would need to be built well out into the river channel. The resultant intake point could be several hundred feet from the present shoreline. A sophisticated intake structure design would need to be constructed to prevent blockage. Due to the intake design requirements, a potential hazard to boat/barge traffic would be created, therefore, requiring surface warning devices. With the complexities previously discussed, the project's cost for such an intake device would be prohibitive. It seems more practical to anticipate dredging on an anticipated five-year basis to open the pump station intake to the river. Some protective measures for the pump station during such dredging activities would be required as well as cleanout of the station itself.

C. Cost Allocation

Often, when construction costs are shared between two or more entities, it is based upon ownership or jurisdictional area. Ideally, cost allocation should occur on some measurable basis that is correlated to the benefits received. To assist with future potential cost sharing agreements between the City of Omaha and the City of Carter Lake, the areas have been calculated within each jurisdiction in two manners:

The drainage basin areas that are within each jurisdiction were first measured. It was found that 62.3% of the contributing drainage area is within the City of Omaha whereas the remaining 37.7% is within the City of Carter Lake.

Secondly, in an effort to achieve a more equitable proration, the area of each jurisdiction was calculated as being "weighted" based upon the various land uses. Calculations were performed with the use of representative runoff coefficients for each land use category. This allowed for a proration basis that was directly correlated to the amount of runoff that would arrive at Carter Lake, not only rainfall amounts. The enclosed table entitled "Jurisdictional Area Distribution" summarizes the results of these two proration methods. As shown, weighting the area calculation results in percentages of 61.7% and 38.3% for the City of Omaha and City of Carter Lake, respectively.

Jurisdictional Area Distribution

LAND USE CATEGORY	RUNOFF COEFF.	CITY OF OMAHA			CITY OF CARTER LAKE		
		AREA (km^2)	AREA (acre)	CxA (acre)	AREA (km^2)	AREA (acre)	CxA (acre)
LOW DENSITY RESIDENTIAL	0.60	2.01	495.55	297.33	2.72	671.24	402.75
CIVIC/ INSTITUTIONAL	0.85	0.06	16.01	13.61	0.00	0.00	0.00
PARK/ OPEN SPACE	0.30	1.24	305.72	91.72	0.00	0.00	0.00
INDUSTRIAL	0.80	1.16	287.12	229.70	0.00	0.00	0.00
OFFICE/COMMERCIAL	0.90	0.02	4.03	3.63	0.27	67.02	60.32
HIGN DENSITY RESIDENTIAL	0.70	0.02	4.87	3.41	0.00	0.00	0.00
WATER BODY	0.95	1.01	249.92	237.43	0.35	85.28	81.02
	TOTAL	5.52	1363.22	876.81	3.33	823.55	544.08

Summary:

1.) FLAT AREA PRORATION:

CITY OF OMAHA = 62.34%   CITY OF CARTER LAKE = 37.66%

2.) WEIGHTED AREA PRORATION

CITY OF OMAHA = 61.71%   CITY OF CARTER LAKE = 38.29%

D. Conclusion

During significant rainfall events, it is likely that some flood damages to locations surrounding Carter Lake will occur. The goal of the study was to evaluate the feasibility of optimizing the performance of the lake level control systems. The traditional "design storm" approach was not selected but rather a reasonable level of enhanced performance was chosen. In light of the project purpose, the withdrawal system (high water level control) can readily be enhanced as recommended in this study and serve as a reliable component. The existing supply system (low water level control), as constructed, must be modified substantially to achieve a "workable" performance level. An alternative approach, using periodic dredging, is suggested as more cost effective in this instance. Consequently, with this in mind, the next design phase of the project can now be implemented. The enhanced rehabilitated system will provide a "reasonable" level of service at a "reasonable" cost.

Appendix

CONSTRUCTION COST ESTIMATE
CARTER LAKE FORCE MAIN
DUPLEX SYSTEM

ITEM	QUANTITY	UNIT COST	TOTAL
Remove tree and replant 2" diameter	1 Ea.	400.00	400.00
Remove tree 10" diameter	1 Ea.	500.00	500.00
Remove and replace wood fence	30 L.F.	9.00	270.00
Remove and replace chain link fence	30 L.F.	12.00	360.00
Sawcut asphalt	145 L.F.	4.50	652.50
Remove and replace asphalt pavement	78 S.Y.	16.00	1,248.00
Core hole in building wall 24" diameter	1 Ea.	1,600.00	1,600.00
Remove existing pump pit and piping	1 L.S.	1,500.00	1,500.00
Excavation	2,050 C.Y.	3.25	6,662.50
24" water pipe (pressure)	2,470 L.F.	44.00	108,680.00
Backfill	1,715 C.Y.	2.50	4,287.50
Haul excess	335 C.Y.	18.00	6,030.00
30" RCP	36 L.F.	58.30	2,098.80
Inlet structure with gate	1 Ea.	24,000.00	24,000.00
Wet well with sump 10' x 12'	1 Ea.	36,000.00	36,000.00
Rock road	1,980 S.Y.	5.50	10,890.00
Relocate utilities	1 L.S.	14,000.00	14,000.00
Pump, valves, controls (duplex)	1 L.S.	175,000.00	175,000.00
Electrical service	1 L.S.	8,500.00	8,500.00
Fine grade	1,800 S.Y.	1.75	3,150.00
Seed	1,800 S.Y.	.25	450.00
Mobilization	1 L.S.	1,500.00	1,500.00
Traffic control	1 L.S.	250.00	250.00
Subtotal			**408,029.30**
Overhead 15%			61,204.40
Subtotal			**469,233.70**
Profit 10%			46,923.37
Subtotal			**516,157.07**
Contingency 10%			51,615.71
TOTAL			**$567,772.78**

CONSTRUCTION COST ESTIMATE
CARTER LAKE FORCE MAIN
SIMPLEX SYSTEM

ITEM	QUANTITY	UNIT COST	TOTAL
Remove tree and replant 2" diameter	1 Ea.	400.00	400.00
Remove tree 10" diameter	1 Ea.	500.00	500.00
Remove and replace wood fence	30 L.F.	9.00	270.00
Remove and replace chain link fence	30 L.F.	12.00	360.00
Sawcut asphalt	145 L.F.	4.50	652.50
Remove and replace asphalt pavement	78 S.Y.	16.00	1,248.00
Core hole in building wall 24" diameter	1 Ea.	1,600.00	1,600.00
Remove existing pump pit and piping	1 L.S.	1,500.00	1,500.00
Excavation	2,050 C.Y.	3.25	6,662.50
24" water pipe (pressure)	2,470 L.F.	44.00	108,680.00
Backfill	1,715 C.Y.	2.50	4,287.50
Haul excess	335 C.Y.	18.00	6,030.00
30" RCP	36 L.F.	58.30	2,098.80
Inlet structure with gate	1 Ea.	24,000.00	24,000.00
Wet well with sump 10' x 12'	1 Ea.	36,000.00	36,000.00
Rock road	1,980 S.Y.	5.50	10,890.00
Relocate utilities	1 L.S.	14,000.00	14,000.00
Pump, valves, controls (simplex)	1 L.S.	217,500.00	217,500.00
Electrical service	1 L.S.	8,500.00	8,500.00
Fine grade	1,800 S.Y.	1.75	3,150.00
Seed	1,800 S.Y.	.25	450.00
Mobilization	1 L.S.	1,500.00	1,500.00
Traffic control	1 L.S.	250.00	250.00
Subtotal			**450,529.30**
Overhead 15%			67,579.40
Subtotal			**518,108.70**
Profit 10%			51,810.87
Subtotal			**569,919.57**
Contingency 10%			56,991.96
TOTAL			**$626,911.53**