Engineering Report

HYDROLOGY AND HYDRAULIC STUDY

FOR

LAKEPOINT DEVELOPMENT

December 1986

Mid-Kansas Engineering Consultants

I. INTRODUCTION

A. General: The following report outlines the hydrologic and hydraulic analyses that has been completed in conjunction with the design of the improvements for the Lakepoint Development. The development is located in the City of Wichita, Kansas. The area is generally between Central Avenue and 13th Street and west of Webb Road.

This report will address the effect of the development on floodflow carried in the East Branch of Gypsum Creek and changes in the water surface profiles from those predicted in the 1986 Federal Emergency Management Agency (FEMA) Study. The FEMA report entitled "Flood Insurance Study" is dated May 15, 1986 and provides the basis for the City's flood insurance program.

B. Basin Description: The total drainage basin above the Central Avenue crossing is 1630 acres (2.55 sq. mi.). The area is outlined on Figure 1. The basin is presently in the developing stages and can be expected to be fully developed in the next few years. A more detailed discussion of the basin is included in Section IV.

C. Proposed Development: The Lakepoint Development consists of an area of approximately 221 acres that is being developed as residential housing. Living units consist of a combination of single family, patio home, and apartments. The present lakes that are on the property will be redeveloped and expanded to provide the focal point for the area.

A general layout for the development is provided in the appendix. The channel will be crossed at two points by Gatewood Street. Flow under the street crossings will be carried by multiple barrel reinforced concrete boxes (RCB). The lower of the two RCB's will be built in conjunction with the concrete control structure for the lower lake. The control structure will be a concrete weir that provides maximum discharge capacity during high flows. The two middle lakes will also be controlled by concrete weirs. The upper RCB will also be modified to serve as a control structure for the upper lake.

D. Purpose: The purpose of this report is to (1) develop the hydrologic data for the basin, (2) develop water surface profiles for the proposed development, (3) establish floodway limits for development of lots and building pads, and (4) provide the necessary information and calculations for a revision request to FEMA for an update of the information contained in the Flood Insurance Study.

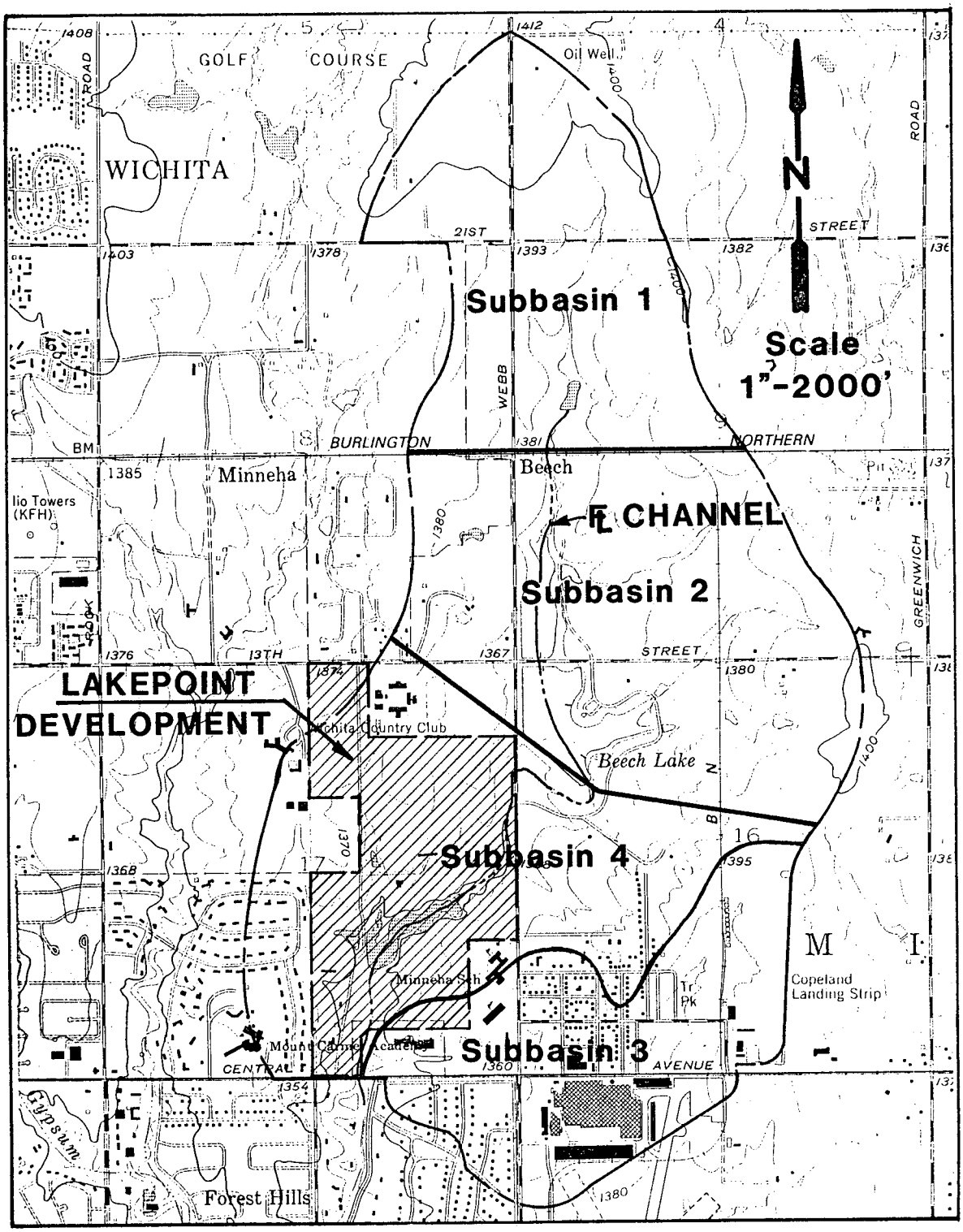

WICHITA
GOLF COURSE
Oil Well
ROAD
21ST
STREET
Subbasin 1
Scale
1"-2000'
WEBB
BURLINGTON
NORTHERN
Minneha
Beech
CHANNEL
Subbasin 2
GREENWICH
LAKEPOINT
DEVELOPMENT
Wichita Country Club
Beech Lake
Subbasin 4
Minneha Sch
Tr Pk
Copeland
Landing Strip
Mount Carmel Academy
CENTRAL
Subbasin 3
AVENUE
Gypsum
Forest Hills
lio Towers
(KFH)
13TH

Figure 1

II. FEMA STUDY

A. The "Flood Insurance Study" prepared by FEMA for the City of Wichita was accepted on May 15, 1986. The study was the culmination of work that was started by the U.S.G.S. in the middle 1970's. During the same time period, FEMA also compiled a similar study for Sedgwick County that covered the unincorporated areas of the county. The Lakepoint Development includes both areas in the City and County studies.

The City study includes the area from Central to about 600 feet north while the county study covers the remaining upstream area through Webb Road.

B. Hydrology and Methodology: The hydrology for the FEMA report was completed using TR 55. The model assumed no upstream constraints such as existing reservoirs, road embankments, etc. that might provide additional storage and thus reduce downstream park flows.

In volume I of the "Flood Insurance Study" for the City of Wichita, the following information was presented concerning the discharges from the East Branch of Gypsum Creek.

Drainage Area	=	2.76 sq. miles (at confluence)
10 Year Flow	=	1550 cfs
50 Year Flow	=	2270 cfs
100 Year Flow	=	2590 cfs
500 Year Flow	=	3310 cfs

These flows were used for the reach of channel between the confluence and Central Avenue. In reviewing the files of the FEMA study, we found no record of any hydrology or water surface profiles generated for the area upstream or north of Central Avenue.

C. Hydraulics: The water surface profiles in the FEMA report were developed by the HEC II computer program. The profiles extended from the confluence of the East Branch of Gypsum Creek to 50 feet upstream of Central Avenue. These profiles produced the following elevations for the 100 year water surface in the vicinity of Central Avenue.

U.S.G.S. Station	Description	Distance Between Stations (ft.)	Water Surface Elevation (U.S.G.S.)	Channel Velocity (fps)
4219	Downstream of Central		1345.53	3.69
		50		
4269			1345.54	4.75
		1		
4270	South End Central RCB		1345.64	4.25
		61		
4331	North End Central RCB		1346.01	3.09
		1		
4332			1346.00	3.52
		50		
4382	Upstream of Central		1346.05	3.40

No water surface elevations were calculated above this point. Flood limits were established by FEMA by using "approximate" methods.

III. PROPOSED DRAINAGE SYSTEM

A. **Downstream:** The existing system downstream of Lakepoint Development will not be changed by the proposed improvements. There is presently an existing triple 10 x 9 RCB under Central Avenue. The RCB is 62 feet in length with 45° wing walls at each end. This structure does create some backwater in the upstream channel, but is adequate to handle the required flows.

B. **Central Avenue to the South crossing of Gatewood:** The existing channel through this area meanders through a heavy stand of brush and timber. The improved channel in the area will be developed to protect as much of the timber as possible while providing the required capacity. The new channel will be trapezoidal and grass lined with a 10 foot bottom and 4.1 side slopes. A five barrel 9 x 5 RCB will be provided at the crossing of Gatewood (south). Figure 2 outlines the proposed channel flowline through this area as well as those in the other reaches.

C. **South Gatewood Crossing to North Gatewood Crossing:** The lower of the three lakes in the development will be controlled by a concrete weir structure constructed just upstream of the RCB. The weir will be set at elevation 154 and provide 55 feet of weir length. The surface area of this lake will be about 1.6 acres.

The second lake will be controlled by a concrete weir set at elevation 160. This structure will provide 100 feet of weir length. This lake contains a surface area of 3.5 acres and includes much of the area that was included in the original lake.

The discharge over the weir will drop to elevation 154 (lower lake surface) as it goes over the weir. The area below the weir will be protected by either concrete paving or large riprap to eliminate erosion and undercutting.

The concrete weir for the third lake will be set at elevation 161, provide 125 feet of weir length and produce a lake with a surface area of 3.0 acres.

The lake will extend northeast to the north crossing where the Gypsum Creek flow will be carried by a 5 barrel 9 x 5 RCB.

D. **North Gatewood Crossing to Webb Road:** The last lake in the development will be controlled by a concrete weir directly upstream of the new RCB. The weir will be set at elevation 162 and provide 135 feet of weir length. The weir will drop the flow about 3 feet to the floodline of the RCB. The actual normal pool of the lake will be extended about 900 feet upstream of the weir where the channel will be basically allowed to maintain its existing condition to Webb Road.

IV. HYDROLOGY

A. Discussion of Basin: The basin above Central Avenue consists of four key subbasins. They are outlined in Figure 1. Subbasin 1 lines north of the Burlington Northern Railroad with the flow metered through an existing 11 x 9 RCB. Flow from the subbasin enters subbasin 2 and is metered through Beech Lake. Subbasins 1 and 2 then flow into subbasin 4 and through the existing lake on the site. The other subbasin collects flow east of Lakepoint and drains into the East Branch of Gypsum Creek just upstream of Central Avenue.

The basin is developing in a number of locations. It is anticipated that total development of the basin will be basically of residential type with limited scattered commercial.

The soil types were reviewed in conjunction with the SCS Hydrologic Soil Grouping. The soil grouping for the major portion of this drainage basin is type "D" with less than five percent of the drainage basin having type "B" soil. The SCS curve numbers utilized for subbasins within the drainage area are presented in Table I.

B. Hydrology and Methodology: The hydrologic calculations were completed using the SCS TR 20 method and computer program. For calculation purposes the basin was divided into a number of subbasins to better predict the actual CN valve to be used. These numbers are outlined in Table I.

The TR 20 was also used to route the flow through the basin to account for existing constraints and storage in the basin. The two major constraints occur at the Burlington Northern Railroad crossing, where there is an existing 11 x 9 RCB, and the storage of flow through Beech Lake. (Neither of these were considered in the FEMA study).

The drainage areas used in this study differed from those used by FEMA. The following is a summary of the drainage areas used.

Location	Drainage Area (for TR 20)	FEMA
Total Basin	3.03 sq. mi.	2.76 sq. mi.
Above Central	2.71 sq. mi.	
Above Section 3 (800 ft. upstream of Central)	2.18 sq. mi.	

TABLE I
SCS RUNOFF CURVE NUMBERS

Subbasin	CN	Land Usage
Area, N. of 21st & W. of Webb Road (Tallgrass)	88	Mixed-Multifamily, detached; Residential; Golf Course; Water Pumping Station
Area N. of 21st & E. of Webb Road (Tallgrass East)	88	Mixed - Residential; Golf Course; Commercial (Proposed)
Area W. of Webb Rd., S. of 21st, N. of R.R.	92	Mixed - 50% Apartment & 50% Single Family Residential
Area, E. of Webb Rd. between 21st St. & proposed 19th St.	91	Mixed - Commercial; Residential; Multifamily Attached
Area, E. of Webb Rd. between proposed 19th St. & R.R.	90	Mixed - Residential; Church Multifamily, attached & detached
Beech Lake Recreation Area & Foliage	82 85	Open Space & Residential
Beech Lake Recreation Area, S. of Lake	80	Open Space
Area, W. of Webb Rd., S. of Foliage & N. of 13th St.	80	Pasture
Rounds & Porter Property	80	Lakepoint Development
Area, S. of Beech Lake Recreation Area & N. of Central Ave.	92	Mixed-Commercial & Residential 1/4 acre or less
Area, S. of Central, & E. of Webb Rd.	97	Commercial
Area, S. of Central, & W. of Webb Rd.	87	Residential, 1/3 acre lot

The majority of flow through the development would be associated with section 3. This section is upstream of the confines of the east subbasin that enters the system through the Art Institute channel.

The shape and size of this basin produces a 100 year hydrograph that is quite sensitive to the rainfall distribution. In order to better review this sensitivity, four rainfall distributions were used to develop the hydrographs. These four included the following;

(1) 24 hour SCS rainfall distribution

(2) 6 hour SCS rainfall distribution

(3) 6 hour Weather Bureau rainfall distribution

(4) SCS TR 60 rainfall distribution

These four distributions produced a variance of about 50 percent in the 100 year peak flow. In review of flows generated from the various distributions, several items should be considered.

(1) The 24 hour and 6 hour SCS distributions each have one peak hour that exceeds 3 inches. In larger rural basins this peak hour is dampened by longer time of concentrations. In a smaller basin such as this, the peak hour tends to inflate the peak flow.

(2) The 6 hour weather bureau distribution is developed directly from the rainfall-intensity-duration curves as represents a two hour 100 year rainfall. The major problem with this distribution occurs when the time of concentration is 15 minutes or less at which point it tends to underestimate peak flow.

(3) The TR-60 was developed for dam design which is more sensitive to volume than peak inflow. The TR-60 uses a more constant rainfall and thus produces a longer flatter hydrograph.

A summary of the 100 year peak flows is shown in Table II. For comparison purposes the table includes the: (1) flows generated from all four rainfall distributions, (2) the estimated peak flow for the basin if no upstream constraints were considered and (3) the flows used by FEMA.

After reviewing the information in Table II it was felt that the flows developed by the Weather Bureau distribution and assuming the upstream constraints best depicted the actual 100 year flow in

TABLE II
100 YEAR PEAK FLOW COMPARISON (cfs)

Description	Total Basin	Above Central	Above Section 3*
FEMA - With no upstream constraints, Total Drainage Area = 2.76 sq. mi.	2590	2590	-
With upstream constraints, Total Drainage Area = 3.03 sq. mi. Drainage Area above Central 2.71 sq. mi. Drainage Area above Section 3 = 2.18 sq. mi.			
a. 24 hr. SCS rainfall distribution	2400	1920	1368
b. 6 hr. SCS rainfall distribution	-	1946	1201
c. 6 hr. Weather Bureau rainfall distribution	-	1550	1107
d. TR 60 SCS rainfall distribution	-	1326	1088
MKEC - With no upstream constraints Total Drainage Area = 3.03 sq. mi. Using 24 hr. SCS rainfall distribution	3410	-	-

*Section 3 located 800 ft. upstream of Central

the basins. It was felt , however, that these flows may not be acceptable to FEMA for the following reasons;

(1) The FEMA study tended to use long reaches of constant flow while these flows indicated substantial flow reduction across the site as the drainage basin decreased.

(2) The drainage areas varied by 10 percent.

(3) The previous FEMA work did not include any upstream constraints. It could be argued that at some future date these constraints may be eliminated.

With these items in mind, a design flow of 2000 cfs was chosen for the 100 year peak flow. This flow is slightly above the largest peak flows calculated at Central Avenue (1920 cfs for the 24 hour distribution and 1546 cfs for the 6 hour distribution). In addition, by assuming the 2000 cfs through the entire reach, the precedent established by FEMA concerning limited changes in flow is continued.

While the choice of 2000 cfs for the upper reach of the development does produce a very conservative estimate of flow, it did not effect the design drastically because of the wide floodway provided by the lakes.

V. WATER SURFACE PROFILES

The water surface profiles were developed using the HEC II computer program. The model was initiated several hundred feet downstream of Central Avenue using critical depth and multiple cross sections to bring the water surface up to normal depth.

This form of analysis assumes that the weir structures are able to pass the floodflow with limited backwater. The lakes then act as a wide channel to carry flow.

In the process of review and design approximately 25 different profiles were developed. These profiles used the various flows as outlined in Table I in combination with structural changes in the RCB's and weir structures.

Although the FEMA study gave no actual water surface elevations in this area, by overlaying the flood boundary map on a contour map, crude estimates of the water surface elevations can be made. From these numbers, it appears the 100 year water surface elevation will be reduced several feet with construction of the proposed development.

The flood plain sections and stationing used in the analysis are shown in Figure 2 in the appendix. A summary of the information generated by the HEC II run is outlined in Table III. This same information is shown in graphical form on Figure 3.

The floodway limits as shown on Figure 2 were developed by using the sections applied to the model in conjunction with the water surface elevations generated by the computer program. The intent of the floodway boundary is to indicate limits that cannot be encroached upon without changing the water surface elevations. This will allow for earthwork and filling operations to take place outside the floodway and not effect the floodflow.

TABLE III
WATER SURFACE PROFILE INFORMATION

Station	Description	Distance Between Sections (feet)	100 Year Water Surface Elevation	Channel Velocity (fps)
9.00			154.58	6.66
10.00		100	154.81	6.22
10.30		30	154.87	6.14
10.60		30	154.54	7.90
10.70		10	154.55	7.91
11.40	Central Avenue	80	154.67	7.80
11.50		10	154.81	12.92
11.80		30	157.61	2.42
12.00		20	157.38	5.85
17.00		500	157.94	7.06
17.50		50	157.91	6.46
17.80		30	158.29	4.73
18.00		20	157.71	8.89
18.80	Gatewood (south)	80	158.10	8.89
19.00		20	159.18	4.12
24.00		500	159.51	3.27
25.50		150	161.01	7.66
28.80		330	162.20	3.76
29.80		100	162.95	7.82
36.35		655	163.57	4.53
36.50		15	163.93	11.30
37.40	Gatewood (north)	90	165.19	8.89
37.55		15	166.34	4.13
45.00		745	166.80	2.46

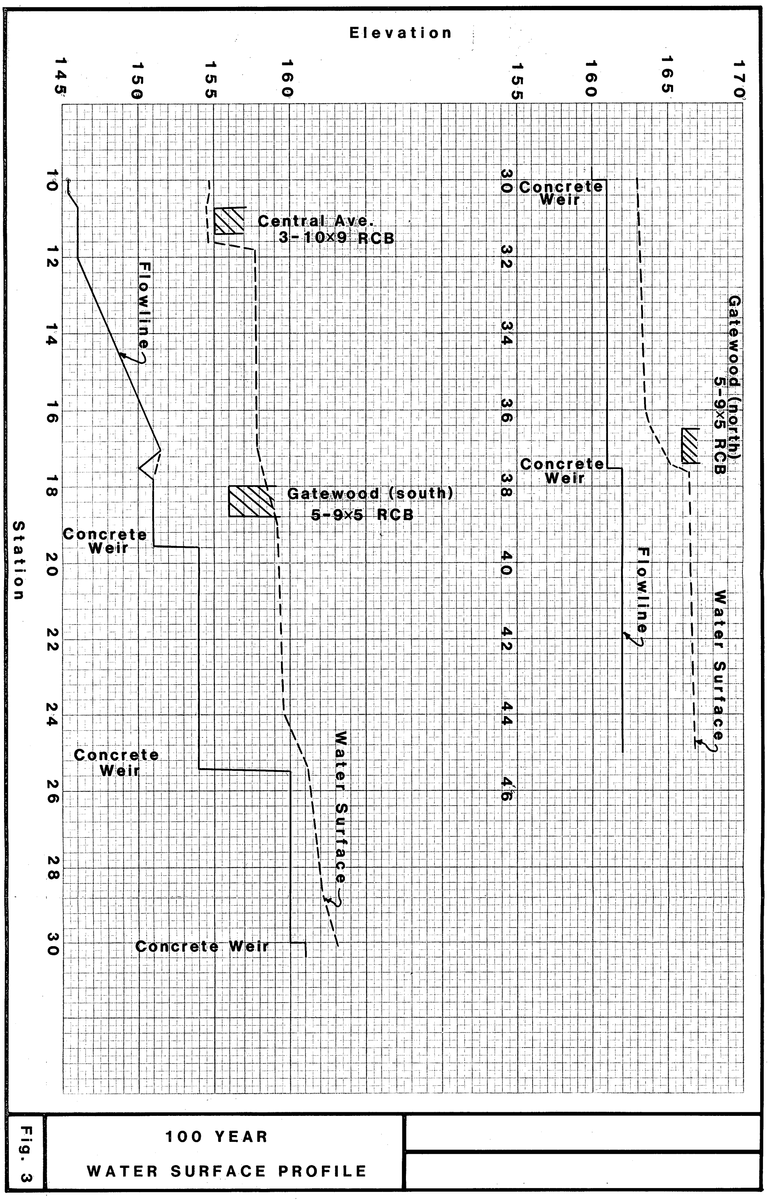


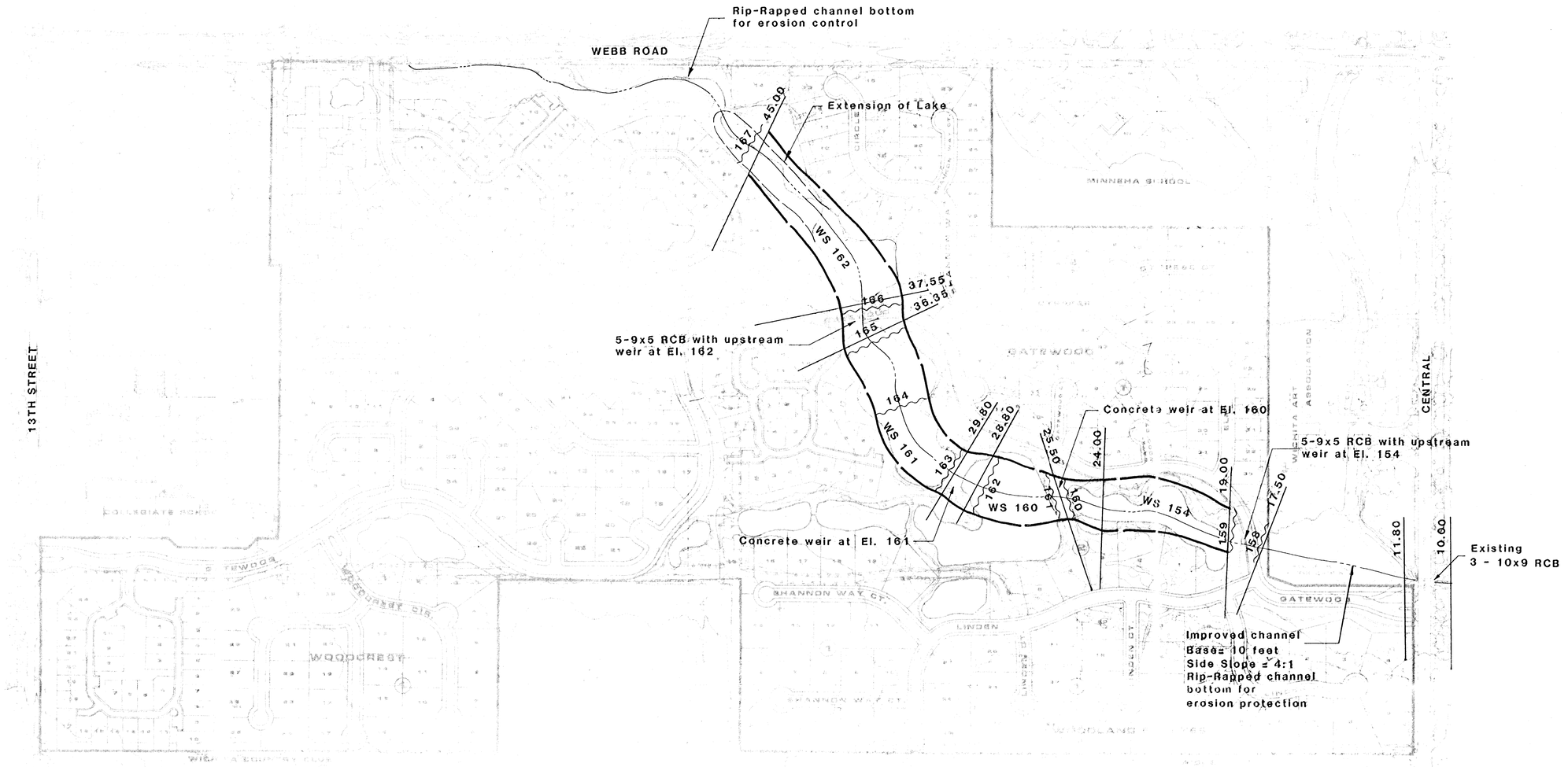
Fig. 3

100 YEAR

WATER SURFACE PROFILE

N

1" - 200'



FLOODWAY WIDTH	
STATION	WIDTH(Ft.)
19.00	150
24.00	205
25.50	160
28.80	230
29.80	170
36.35	240
37.55	240
45.00	190

*NOTE: The term floodway as used in this study indicates the limits of construction encroachment that will cause NO CHANGE in the water surface elevations presented.

LEGEND

- 17.50 — CROSS SECTION LOCATION AND STATION
- FLOOD FLOW CENTERLINE
- FLOODWAY*
- 160 — 100 YEAR WATER SURFACE ELEVATION
- WS 154 — NORMAL LAKE POOL ELEVATION

LAKEPOINT DEVELOPMENT

FLOOD PLAIN MAP

Design JWW
Drawn by BMS
Checked by JLM
Date Dec 1986
Job no

MID-KANSAS ENGINEERING CONSULTANTS PA
1609 S.W. 37TH.
TOPEKA, KANSAS 66611 266-8462

figure 2