Revised Preliminary Drainage Plan

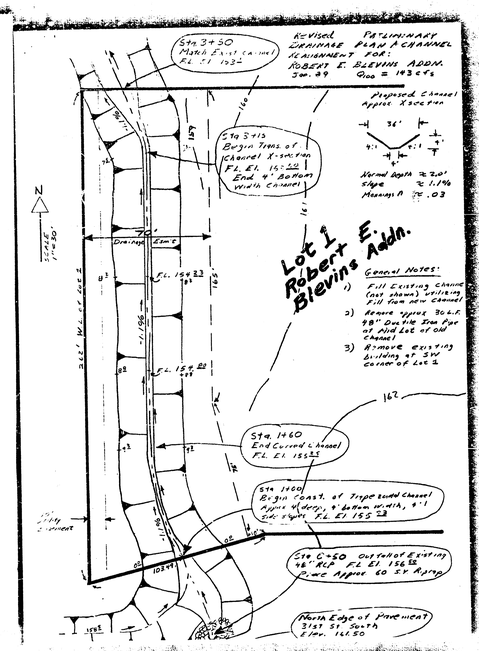
and Channel Realignment for:

Robert E. Blevins Addn. to Wichita,

Sedgwick County, Kansas

Prepared For: The City of Wichita -- Owner
Lowell D. High ------- Platting Surveyor

Prepared By: Robert A. Harrington, P.E.
January, 1989



Revised Preliminary Drainage Plan -- January 1989

Proposed Channel Realignment -- Robert E. Blevins Addition
From Sta. 0+50 to Sta. 3+50 (Approx. N.L. of Addn.)

The proposed channel is a grass lined trapezoid with a 4' bottom width and 4:1 side slopes.
The approximate channel depth is 4', which means the allowable maximum depth of flow is 3' if we want to have 1' of freeboard.

Open Channel Flow Calculations -------- DEPTH

Manning Equation - Trapezoidal Channels
Finding the normal depth of flow d, and the velocity v
Given discharge Q, base width b, side slope z, roughness n, slope s

$Q = (1.486/n) * A * R^{2/3} * S^{1/2}$

Enter the ditch flow slope: s := .011

Enter the base width in feet: b := 4

Enter the side slope ratio horizontal/vertical: z := 4

Enter the value of the roughness coefficient: n := .05

Enter the discharge flow rate in cfs: Q := 143

The formula for velocity of flow is:

$v(d) := \frac{Q}{(b + z \cdot d) \cdot d}$

$A(d) := (b + z \cdot d) \cdot d$

$P(d) := b + 2 \cdot d \cdot \sqrt{1 + z^2}$

$R(d) := \frac{A(d)}{P(d)}$

Proposed Channel Realignment -- Robert E. Blevins Addition
From Sta. 0+50 to Sta 3+50 (Approx. N.L. of Addn.)

We will now find the normal depth of flow 'd' and the average flow velocity 'v'

$K_{AR}(d) := \left[\frac{1.486}{n}\right] \cdot A(d) \cdot R(d)^{\frac{2}{3}} \cdot s^{\frac{1}{2}}$

Guess d := 1

Given

$Q = K_{AR}(d)$

$d := \text{find}(d)$

d = 2.0285 feet ✓OK Normal depth is O.K. Leaves approx. 2 feet of freeboard

$A\left[\frac{d}{n}\right]$ = 24.57332 square feet $P\left[\frac{d}{n}\right]$ = 20.72747 linear feet

$R\left[\frac{d}{n}\right]$ = 1.18554 feet $v\left[\frac{d}{n}\right]$ = 5.81932 feet per second ✓OK Velocity is permissible

Now compute the product of velocity and hydraulic radius -- this is mainly of use for grassy channels as a check on the appropriate Mannings n

$R(d) := \frac{(b + z \cdot d) \cdot d}{b + \left[2 \cdot d \cdot \sqrt{1 + z^2}\right]}$ $VR := v\left[\frac{d}{n}\right] \cdot R\left[\frac{d}{n}\right]$ VR = 6.89906

For Petition Purposes Only, use an estimated construction cost of:

$13,500.00

Use $14,000

Preliminary Drainage Plan for:

Robert E. Blevins Addn. to Wichita,

Sedgwick County, Kansas

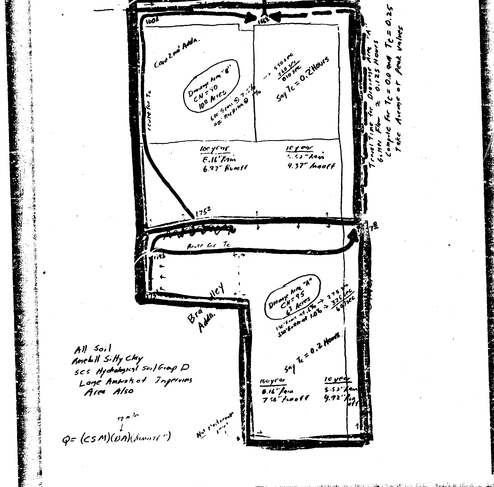
Prepared For: The City of Wichita -- Owner
Lowell D. High ------- Platting Surveyor

Prepared By: Robert A. Harrington, P.E.
December, 1988

Preliminary Drainage Plan for:

Robert E. Blevins Addn. to Wichita,

Sedgwick County, Kansas


ROBERT E. BLEVINS ADDN.
Existing Condition DRNG
Q100 = 193 cfs
Q10 = 91 cfs
Drainage Area A = 6.3 Acres
Drainage Area B = 10.0 Acres
Drainage Area C = 2.4 Acres
Sq. Ft. = 0.35 Acres
Tc = 0.08 Hours
Tc = 0.125 Hours
Tc = 0.17 Hours
Tc = 0.33 Hours
Tc = 0.55 Hours
Tc = 0.83 Hours
10 YEAR 6.11" Rain 6.97" Runoff
100 YEAR 9.53" Rain 10.87" Runoff
Curb Inlet
Drainage Area "A" 6.3 Acres
Drainage Area "B" 10.0 Acres
Drainage Area "C" 2.4 Acres
Sq. Ft. = 0.2 Acres
Flow Line Elev. 156.55
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Flow Line Elev. -10.22
Flow Line Elev.

Type I | 1958 | Open Channel Flow, by Ven Te Chow, McGraw-Hill, 1959

Culvert Capacity

Assume Type I entrance

Assume Area = 15.07 (1.1" of freeboard)

Be an optimist - neglect entrance friction losses $h_{f(1-2)} = 0$

Be an optimist - assume $C_D = 0.95$

At Area 15.07 the typical channel will be flowing approximately full with a cross sectional area of 15.07 ft²

Velocity at approach = $\frac{Q}{A_{ch}}$ = 1.43 ft/sec

Be an optimist - say $\bar{\alpha}_1 = 1.5$ ft/sec

$z = 15.07 - 14.49 = .326$

$h_v = 15.07 - 15.491 = 9.76'$

Critical depth $d_c = y_c = 2.96$ feet

Critical Area A_c = 9.93 s.f. - call it 10 s.f. Let $\alpha = 1$

$$Q = C_D A_c \sqrt{2g\left(h_1 - z + \alpha_1 \frac{\bar{v}_1^2}{2g} - y_c - h_{f(1-2)}\right)}$$

$$Q = (0.95)(9.95)\sqrt{(2\cdot32.2)\left(4.26 - .28 + \frac{1.5^2}{2\cdot32.2} - 2.96 - 0\right)}$$

$$Q = (0.93)(9.95)\sqrt{69.026} = 78.6\ cfs$$

2nd Cut — Let $Q = 78.6$ cfs. Keep C_D at 0.95, allow α_1 to make the math easy

$h_1 = 4.26'$ unchanged

$z = .28'$ unchanged

$h_v = 8.72'$

$d_c/y_c = 2.62'$

$\bar{v}_1 = \frac{78.6}{10} = 1.12$ fps

Conclusion: Existing Culvert is too small

$Q = (0.95)(10)\sqrt{(2\cdot32.2)\left(4.28 - .028 + \frac{1.12^2}{2\cdot32.2} - 2.62 - 0\right)}$

$Q = (0.93)(10)\sqrt{70.12}$ — Q = 78.6 cfs is far below what is required or allowable — need 143 cfs

CULVERT HAS INSUFFICIENT CAPACITY.

Open Channel Flow Calculations -------- DEPTH — Blevins Addn — Sta. 2400 - 3400

Manning Equation - Trapezoidal Channels
Finding the normal depth of flow d, and the velocity v
Given discharge Q, base width b, side slope z, roughness n, slope s

$$Q = (1.486/n) * A * R^{2/3} * S^{1/2}$$

Enter the ditch flow slope: s := .005

Enter the base width in feet: b := 20

Enter the side slope ratio horizontal/vertical: z := 2.5

Enter the value of the roughness coefficient: n := .05

Enter the discharge flow rate in cfs: Q := 143

$$K_{AR}(d) := \frac{((b + z\cdot d)\cdot d)^{\frac{5}{3}}}{[b + 2\cdot d\sqrt{1 + z^2}]^{\frac{2}{3}}}$$

The formula for velocity of flow is:

$$v(d) := \frac{Q}{(b + z\cdot d)\cdot d}$$

We will now find the normal depth of flow: "d" and the average flow velocity "v"

Guess d := 2.

Given

$$K_{AR}(d) = \frac{n\cdot Q}{1.486\sqrt{s}}$$

d_n := find(d) d_n = 1.983 feet ← Leaves 2' of freeboard plenty adequate

$v\left[\frac{d}{n}\right]$ = 2.89 feet per second

Now compute the product of velocity and hydraulic radius -- this is mainly of use for grassy channels as a check on the appropriate Mannings n

$$R(d) := \frac{(b + z\cdot d)\cdot d}{b + \left[2\cdot d\sqrt{1 + z^2}\right]} \qquad VR := v\left[\frac{d}{n}\right] R\left[\frac{d}{n}\right] \qquad VR = 4.662$$

Now compute the critical depth for this channel and discharge:

Top width T(d) is defined as follows:

T(d) := b + 2·d·z

Cross sectional area of a trapezoidal channel is defined as follows:

A(d) := (b + d·z)·d

To find minimum specific energy, solve the following:

Guess d := d_n ·.30

Given

$$\frac{A(d)^3}{T(d)} = \frac{Q^2}{32.2}$$

d_c := find(d) d_c = 1.112

Open Channel Flow Calculations -------- DEPTH — Blevins Addn — Sta 3400 - 3750

Manning Equation - Trapezoidal Channels
Finding the normal depth of flow d, and the velocity v
Given discharge Q, base width b, side slope z, roughness n, slope s

$$Q = (1.486/n) * A * R^{2/3} * S^{1/2}$$

Enter the ditch flow slope: s := .018

Enter the base width in feet: b := 20

Enter the side slope ratio horizontal/vertical: z := 2.5

Enter the value of the roughness coefficient: n := .05

Enter the discharge flow rate in cfs: Q := 143

$$K_{AR}(d) := \frac{((b + z\cdot d)\cdot d)^{\frac{5}{3}}}{[b + 2\cdot d\sqrt{1 + z^2}]^{\frac{2}{3}}}$$

The formula for velocity of flow is:

$$v(d) := \frac{Q}{(b + z\cdot d)\cdot d}$$

We will now find the normal depth of flow: "d" and the average flow velocity "v"

Guess d := 2'

Given

$$K_{AR}(d) = \frac{n\cdot Q}{1.486\sqrt{s}}$$

d_n := find(d) d = 1.374 feet ← Leaves 2.6' of freeboard plenty adequate

$v\left[\frac{d}{n}\right]$ = 4.441 feet per second

Now compute the product of velocity and hydraulic radius -- this is mainly of use for grassy channels as a check on the appropriate Mannings n

$$R(d) := \frac{(b + z\cdot d)\cdot d}{b + \left[2\cdot d\sqrt{1 + z^2}\right]} \qquad VR := v\left[\frac{d}{n}\right] R\left[\frac{d}{n}\right] \qquad VR = 5.219$$

Now compute the critical depth for this channel and discharge:

Top width T(d) is defined as follows:

T(d) := b + 2·d·z

Cross sectional area of a trapezoidal channel is defined as follows:

Proposed x section is a trapezoid with 8' bottom width, 3:1 side slopes
Approximate channel depth is 4' (means maximum flow depth is 3', we have one foot of freeboard

Open Channel Flow Calculations -------- DEPTH

Manning Equation - Trapezoidal Channels
Finding the normal depth of flow d, and the velocity v
Given discharge Q, base width b, side slope z, roughness n, slope s

$$Q = (1.486/n) * A * R^{2/3} * S^{1/2}$$

Enter the ditch flow slope: s := .01133

Enter the base width in feet: b := 8

Enter the side slope ratio horizontal/vertical: z := 3

Enter the value of the roughness coefficient: n := .05

Enter the discharge flow rate in cfs: Q := 143

$$K_{AR}(d) := \frac{((b + z\cdot d)\cdot d)^{\frac{5}{3}}}{[b + 2\cdot d\sqrt{1 + z^2}]^{\frac{2}{3}}}$$

The formula for velocity of flow is:

$$v(d) := \frac{Q}{(b + z\cdot d)\cdot d}$$

$$A(d) := (b + z\cdot d)\cdot d$$

$$P(d) := b + 2\cdot d\sqrt{1 + z^2}$$

$$R(d) := \frac{A(d)}{P(d)}$$

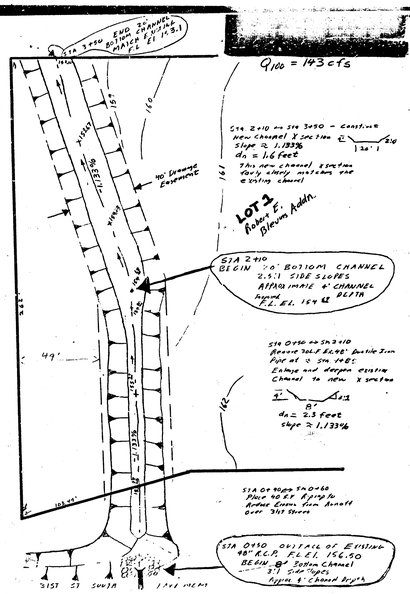
Preliminary Drainage Plan for:

Robert E. Blevins Addn. to Wichita,

Sedgwick County, Kansas

Proposed Drainage Plan

Blevins Addition



To find minimum specific energy, solve the following:

Guess d := d_n

Given

$$\frac{A(d)^3}{T(d)} = \frac{Q^2}{32.2}$$

d_c := find(d) d_c = 1.72152

Note that the normal depth is greater than the critical depth. However, this should not cause much of a problem, since there are (after removing the existing old Addn. 48" pipe) no significant flow obstructions, the velocity is within allowable limits for a grass lined channel on clay soil, and the flow is only intermittent.

Proposed x section closely matches the existing channel and is a trapezoid with 20' bottom width and 2.5:1 side slopes.
The approximate channel depth is 4', which means the allowable maximum depth of flow is 3' if we want to have 1' of freeboard.

Open Channel Flow Calculations -------- DEPTH

Manning Equation - Trapezoidal Channels
Finding the normal depth of flow d, and the velocity v
Given discharge Q, base width b, side slope z, roughness n, slope s

$$Q = (1.486/n) * A * R^{2/3} * S^{1/2}$$

Enter the ditch flow slope: s := .01133

Enter the base width in feet: b := 20

Enter the side slope ratio horizontal/vertical: z := 2.5

Enter the value of the roughness coefficient: n := .05

Enter the discharge flow rate in cfs: Q := 143

The formula for velocity of flow is:

$$v(d) := \frac{Q}{(b + z\cdot d)\cdot d}$$

$$A(d) := (b + z\cdot d)\cdot d$$

$$P(d) := b + 2\cdot d\sqrt{1 + z^2}$$

$$R(d) := \frac{A(d)}{P(d)}$$

We will now find the normal depth of flow: "d" and the average flow velocity "v"

$$K_{AR}(d) := \left[\frac{1.486}{n}\right] A(d)^{\frac{5}{3}} R(d)^{\frac{2}{3}} s^{\frac{1}{2}}$$

Guess d := 1

Given

$$Q = K_{AR}(d)$$

d_n := find(d)

d_n = 1.57005 feet Leaves approx. 2.4 feet of freeboard

$A\left[\frac{d}{n}\right]$ = 37.56354 square feet $P\left[\frac{d}{n}\right]$ = 28.45496 linear feet

$R\left[\frac{d}{n}\right]$ = 1.32011 feet $v\left[\frac{d}{n}\right]$ = 3.80688 feet per second

Now compute the product of velocity and hydraulic radius -- this is mainly of use for grassy channels as a check on the appropriate Mannings n

$$R(d) := \frac{(b + z\cdot d)\cdot d}{b + \left[2\cdot d\sqrt{1 + z^2}\right]} \qquad VR := v\left[\frac{d}{n}\right] R\left[\frac{d}{n}\right] \qquad VR = 5.02549$$

Now compute the critical depth for this channel and discharge:

Top width T(d) is defined as follows:

T(d) := b + 2·d·z

Cross sectional area of a trapezoidal channel is defined as follows:

A(d) := (b + d·z)·d

To find minimum specific energy, solve the following:

Guess d := d_n

Given

$$\frac{A(d)^3}{T(d)} = \frac{Q^2}{32.2}$$

d_c := find(d) d_c = 1.11151

Note that the normal depth is greater than the critical depth. However, this should not cause much of a problem, since there are (after removing the exising old Addn. 48" pipe) no significant flow obstructions, the velocity is within allowable limits for a grass lined channel on clay soil, and the flow is only intermittent.

Cost Estimate (for Petition Purposes Only) for Drainage Improvements in Robert E. Blevins Addition

Quantity	Units	Item	Cost/Unit	Total
200.00	C.Y.	Excavation	2.50	500.00
150.00	C.Y.	Compacted Fill	2.50	375.00
40.00	S.Y.	Riprap	20.00	800.00
0.30	Acres	Grass Seeding, Mulch Etc.	1200.00	360.00
1.00	L.S.	Remove 36 L.F. 48" Ductile Iron Pipe	500.00	500.00
1.00	L.S.	Clear/Clean Drain. Cost., Remove Trash, Debris, Etc.	Incid.	0.00
		Subtotal		82,475.00
		Petition Contingency		371.25
		Engineering		990.00
		Administration		49.50
		Publication		$200.00
		Total		84,085.75

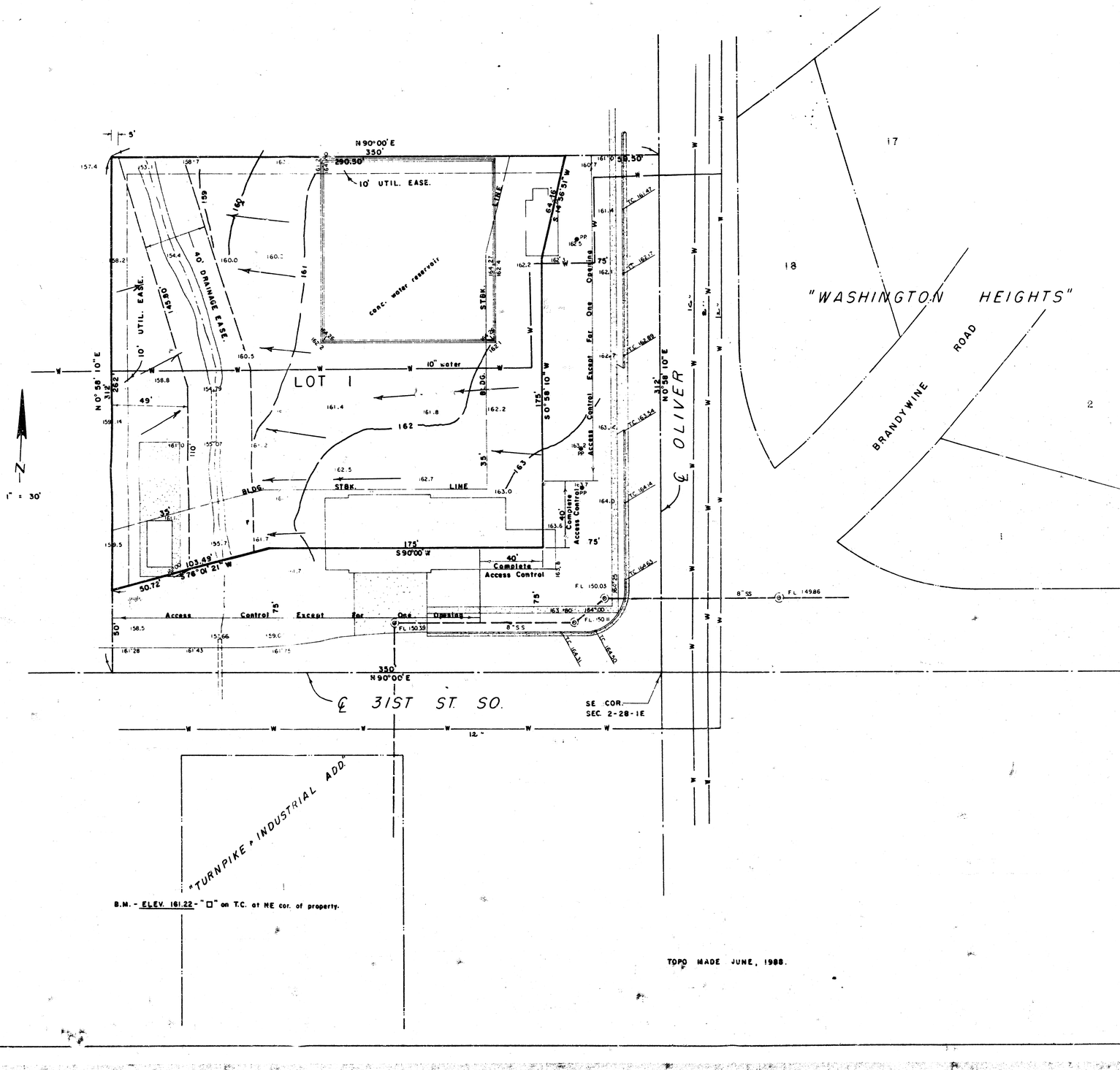
So, say for petition purposes only, call it $5,000.00

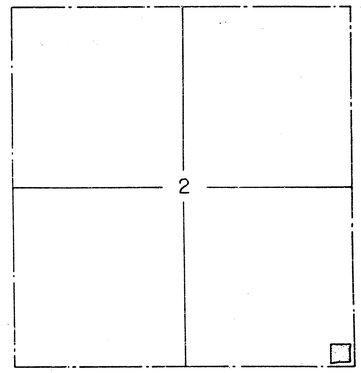
Robert E. Blevins

SKETCH PLAT

ROBERT E. BLEVINS ADDITION,

WICHITA, SEDGWICK COUNTY, KANSAS





VICINITY MAP
1" = 1000'

DRAINAGE PLAN

GRADE LOT TO DRAIN TO DRAINAGE DITCH BY METHOD APPROVED BY THE CITY OF WICHITA.

DRAIN LOT AS SHOWN BY ARROWS.

FOR:
CITY OF WICHITA

B.M. - ELEV. 161.22 - "□" on T.C. at NE cor. of property.

TOPO MADE JUNE, 1988.

LOWELL D. HIGH, L.S.
1542 S. ST. FRANCIS
WICHITA, KS 67211

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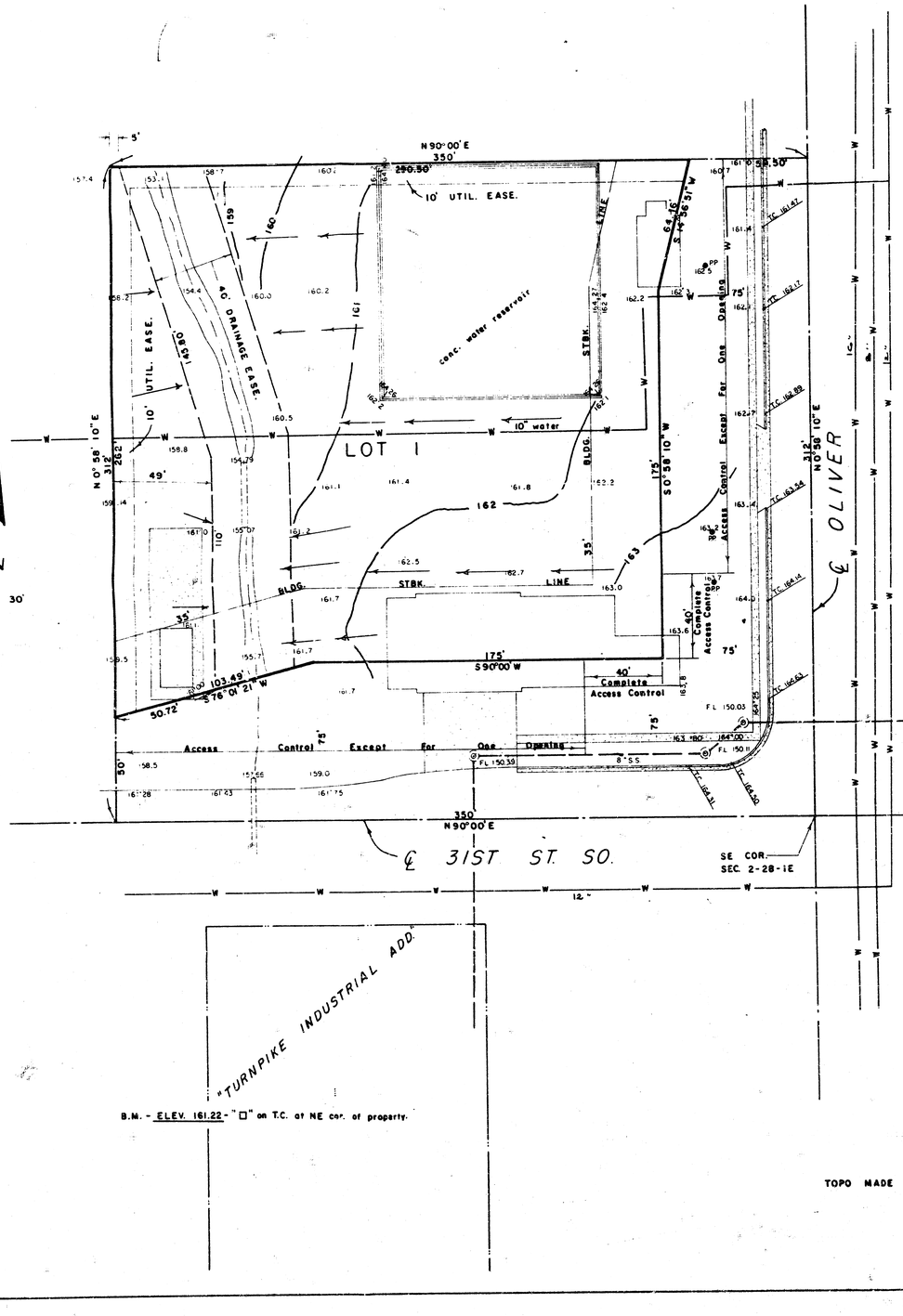
Robert E. Blevins

SKETCH PLAT

ROBERT E. BLEVINS ADDITION,

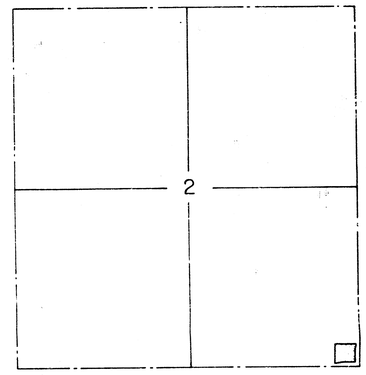
WICHITA, SEDGWICK COUNTY, KANSAS



1" = 30'

B.M. - ELEV. 161.22 - "□" on T.C. at NE cor. of property.

TOPO MADE JUNE, 1988.



VICINITY MAP
1" = 1000'

GRADE PLAN

GRADE LOT TO DRAIN TO DRAINAGE EASEMENT.

FOR:
CITY OF WICHITA

LOWELL D. HIGH, L.S.
1542 S. ST. FRANCIS
WICHITA, KS 67211

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