STORMWATER DETENTION ANALYSIS

CORONATION ESTATES

BAX PROJECT NO. 87-2736

PREPARED FOR:

H.S.P. PARTNERSHIP
4165 INDUSTRIAL DRIVE
ST. CHARLES, MO 63301

PREPARED BY:

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NOVEMBER 20,1989

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I. PURPOSE

The purpose of this report is to estimate the increase in the storm water runoff rate due to development of the tract of land known as "CORONATION ESTATES" and to estimate the attenuation characteristics of the stormwater detention facility that is proposed to be constructed as part of the site improvements. Based upon such estimates, a comparison is made between the pre-developed rate of stormwater runoff and the post-developed rate of stormwater runoff.

II. SCOPE

This report estimates the expected increase in stormwater runoff rate and attenuation characteristics during a 25 year frequency storm of 20 minutes duration, utilizing the rational method of estimating stormwater runoff to the detention facility. In addition, a storm of great intensity is checked for safe passage through the detention facility.

III. DETENTION CONCEPT

The proposed site improvements include construction of a dry detention basin at the south property line of the site. The storage volume and outflow rate have been proportioned to insure that the peak rate of runoff leaving the sub-watershed of the site under post-developed conditions is less than or equal to the peak rate of runoff leaving the sub-watershed of the site under pre-developed conditions for the design storm.

IV. STORMWATER RUNOFF INFORMATION

Runoff calculations for the tract and calculations of required attenuations are shown on Exhibit 'A'.

Estimate Inflow Hydrograph calculations for the design 25 year storm as well at the 15 year and 100 year storm are shown on Exhibit 'B'.

V. DETENTION BASIN CHARACTERISTICS

The depth-storage characteristics of the proposed detention basin are shown on Exhibit 'C'.

Outflow pipe performance calculations are shown on Exhibit 'D'.

VI. ROUTING PROCEDURE

The modified Puls routing procedure was used to estimate the effects of storage volume on outflow rate.

Exhibit 'E' details the development of the routing curves.

Exhibit 'F' displays the routing calculations.

VII. SUMMARY

The proposed detention basin will meet the outflow requirement which is based on the peak rate of runoff for the design storm under pre-developed conditions.

The detention basin is allowed a maximum outflow of 39.96 c.f.s. when considering a 25 year frequency storm of 20 minute duration. The peak outflow for this storm is 39.7 c.f.s. from the basin.

Overflow structure calculations for a 100 year storm have also been checked and shown on Exhibit 'G'.

Graphs of the basin's inflow-time characteristics, depth-storage characteristics, depth-outflow characteristics and the design routing curve hydrograph are all shown on Exhibit 'H'.

E X H I B I T S

General Site Data & Runoff Calculations

1) The tract of land under pre-developed conditions is generally undeveloped, and for the purpose of this analysis, assumed to be 0% to 5% impervious. Therefore the following pre-developed P.I. factors shall be used.

15 year storm : 1.87 cfs/Ac.
25 year storm : 2.31 cfs/Ac.
100 year storm : 2.95 cfs/Ac.

2) The tract of land under post-developed conditions will be a S.F.R. (40% impervious) resulting in the following post-developed P.I. factors.

15 year storm : 2.64 cfs/Ac.
25 year storm : 3.26 cfs/Ac.
100 year storm : 4.17 cfs/Ac.

3) Under pre-developed conditions, peak rate of runoff from the subject tract to the sub-watershed can be estimated as follows :

± 8.88 Ac. x 2.31 cfs/Ac. = 20.51 cfs (25 year storm)

This estimated peak rate (20.51 cfs) shall be considered to be the limiting peak rate under post-developed conditions to the sub-watershed.

EXHIBIT "A"
SHT. 1 OF 3

4) UNDER POST-DEVELOPED CONDITIONS, PEAK RATES OF RUNOFF FROM THE SUBJECT TRACT TO THE TO THE SUB-WATERSHED CAN BE ESTIMATED AS FOLLOWS:

6.10 Ac. x 3.26 cfs/Ac. = 19.89 cfs (F.E.S. #102)
0.42 Ac. x 3.26 cfs/Ac. = 1.37 cfs (DIRECT TO BASIN)
2.36 Ac. x 3.26 cfs/Ac. = 7.69 cfs (BYPASSES BASIN)
28.95 cfs (25 YEAR STORM)

5) THE OFFSITE CONDITIONS FOR THE PURPOSE OF THIS ANALYSIS ARE 3 Ac. TRACTS OF RESIDENTAL HOMES, ASSUMED TO BE 10% TO 15% IMPERVIOUS. THEREFORE THE FOLLOWING OFFSITE P.I. FACTORS SHALL BE USED.

15 YEAR STORM : 2.09 cfs/Ac.
25 YEAR STORM : 2.58 cfs/Ac.
100 YEAR STORM : 3.30 cfs/Ac.

6) THE PEAK RATE OF RUNOFF FROM OFFSITE, NORTH OF THE SUBJECT TRACT, TO THE DETENTION BASIN CAN BE ESTIMATED AS FOLLOWS:

± 10.52 Ac. x 2.58 cfs/Ac. = 27.14 cfs (25 YEAR STORM)

EXHIBIT "A"
SHT. 2 OF 3

7) THE REQUIRED ATTENUATION CAN THEN BE FOUND:

PROJECT TRACT

AREA OF TRACT (x) (POST-DEVELOPED P.I. (-) PRE-DEVELOPED P.I.) =

8.88 Ac. x (3.26 cfs/Ac. - 2.31 cfs/Ac.) =

8.88 Ac. x 0.95 cfs/Ac. = 8.44 cfs

ATTENUATION REQUIRED = 8.44 cfs

Q (cfs) TO BASIN: (25 YEAR STORM)

6.52 Ac. x 3.26 cfs/Ac. = 21.26 cfs (ONSITE)

10.52 Ac. x 2.58 cfs/Ac. = 27.14 cfs (OFFSITE)

48.40 cfs (TO BASIN)

∴ PERMITTED RELEASE RATE =

48.40 cfs (-) 8.44 cfs = 39.96 cfs OK

27.14 (6)

20.51 (3)

47.65

6.23 (BY-PASS DETENT)

41.42 PERMITTED RELEASE RATE

EXHIBIT "A"

SHT. 3 OF 3

INFLOW HYDROGRAPH CALCULATIONS

1) TIME OF CONCENTRATION :

THE MOST REMOTE POINT OF ORIGINATION IS AT THE INTERSECTION OF EMGE ROAD & SUNSET ROAD APPROXIMATELY 600 Ft. NORTH OF D.A.I. #106 (LOCATED @ THE NORTHWEST PROPERTY LINE) AND THEN TRAVEL APPROXIMATELY 474 Ft. VIA STORM SEWER TO THE DETENTION BASIN.

THEREFORE, THE TIME OF CONCENTRATION CAN BE FOUND AS FOLLOWS.

A. 600 Ft. OVERLAND WITH A DIFFERENCE IN ELEVATION OF APPROXIMATELY 20 FEET WHICH RESULTS IN A TOTAL TRAVEL TIME OF 8 MINUTES (OVERLAND FLOW)
(4 MIN. x 2 = 8 MIN. SEE EXHIBIT "B" SHT. 4 OF 4)

B. 474 Ft. OF STORM SEWER WITH AN ESTIMATED VELOCITY (25 YR. STORM) OF 7 FEET PER SECOND WHICH RESULTS IN A TRAVEL TIME OF 1.13 MINUTES
$\left(\frac{474}{1} \times \frac{1}{7 \text{ FT./SEC.}} \times \frac{1 \text{ MINUTE}}{60 \text{ SECONDS}}\right)$

∴ TIME OF CONCENTRATION = 8.0 MIN. (+) 1.13 MIN. = 9.13 MIN. (USE 10 MINUTES)

EXHIBIT "B"
SHT. 1 OF 4

2) AREAS FROM THE DRAINAGE AREA MAP OF THE PROJECT TO THE DETENTION BASIN, THE ESTIMATED PEAK INFLOWS OF 3 DESIGN STORMS ARE:

A. (25 YEAR STORM)

F.E.S. #102 – PROJECT TRACT – 6.10 Ac. x 3.26 = 19.89 cfs
OFFSITE – 10.52 Ac. x 2.58 = 27.14 cfs
DIRECT RUNOFF TO BASIN – 0.42 Ac. x 3.26 = 1.37 cfs
48.40 cfs

(15 YEAR STORM)

F.E.S. #102 – PROJECT TRACT – 6.10 Ac. x 2.64 = 16.10 cfs
OFFSITE – 10.52 Ac. x 2.09 = 21.99 cfs
DIRECT RUNOFF TO BASIN – 0.42 Ac. x 2.64 = 1.11 cfs
39.20 cfs

(100 YEAR STORM)

F.E.S. #102 – PROJECT TRACT – 6.10 Ac. x 3.69 = 22.51 cfs
OFFSITE – 10.52 Ac. x 2.92 = 30.72 cfs
DIRECT RUNOFF TO BASIN – 0.42 Ac. x 3.69 = 1.55 cfs
54.78 cfs

3) THE PERMITTED RELEASE RATE IS 39.96 cfs AS SHOWN IN EXHIBIT "A" (SHEET 3 OF 3)

EXHIBIT "B"

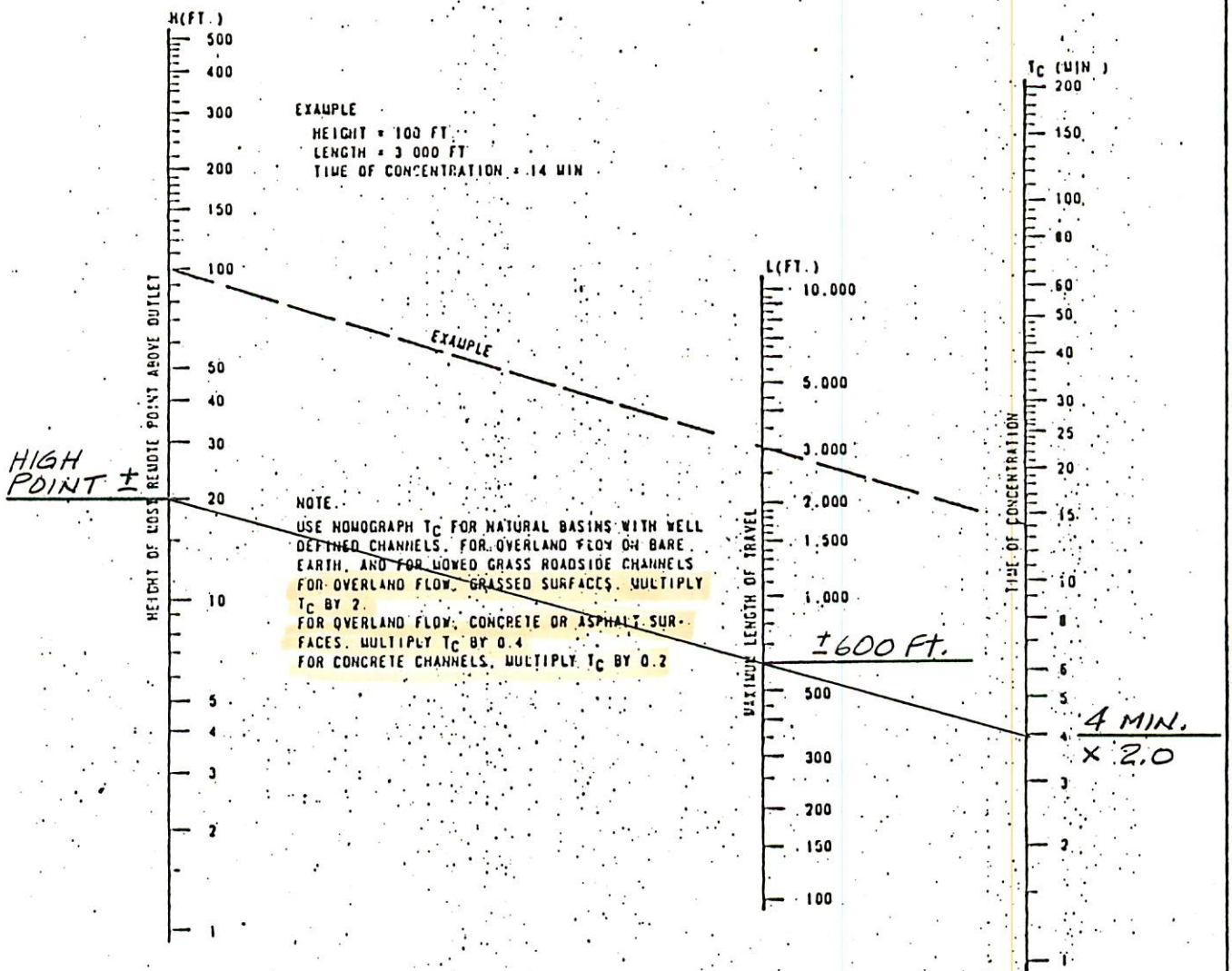

FIGURE 1

TIME OF CONCENTRATION OF SMALL DRAINAGE BASINS

BAX ENGINEERING CO., INC.

LAND PLANNING — LAND SURVEYING — SITE ENGINEERING

EXHIBIT "B"

SHT. 4 OF 4

DEPTH - STORAGE VOLUME CALCULATIONS

ELEVATION	AREA (Ac.)	AVERAGE AREA (Ac.)	INCREMENT OF DEPTH (Ft.)	INCREMENT OF VOLUME Ac./Ft.	TOTAL VOLUME Ac./Ft.
533.0	0				0
		0.022	1.0	0.022	
534.0	0.043				0.022
		0.058	2.0	0.116	
536.0	0.073				0.138
		0.091	2.0	0.182	
538.0	0.109				0.320
		0.115	0.5	0.058	
538.5	0.120				0.378

EXHIBIT "C"

SHT. 1 OF 1

DEPTH - OUTFLOW CALCULATIONS

1) OUTFLOW SHALL BE AN OPENING IN AND OVERFLOW STRUCTURE : FE 533.00 AND SIZE OF OPENING = 3.0'H.(X) 1.38'W. (36"H.(X) 16.5"W.)

2) PERFORMANCE CALCULATIONS :

A. WHEN OPENING IS NOT FLOWING FULL, WEIR FLOW WILL BE ASSUMED.

B. WHEN OPENING IS FLOWING FULL, ORIFACE FLOW WILL BE ASSUMED.

WEIR FLOW $Q = CLH^{3/2}$ $C = 3.0$, $L = 1.375$

ORIFICE FLOW $Q = Ca\sqrt{2gh}$ $C = 0.6$, $a = 4.125$

ELEVATION	h OR H	Q OUT
533.00	0	0
534.00	1	4.125 (WEIR)
535.00	2	11.667 (WEIR)
536.00	3 (WEIR CONTROLS)	21.43 (WEIR or ORIFICE)
537.00	2.5	31.40
538.00	3.5	37.16
538.50	4	39.72

EXHIBIT "D"
SHT. 1 OF 1

ROUTING CURVE CALCULATIONS

LET Δt = 2 MINUTES = 0.033 HOURS

THEN $\frac{2S}{\Delta t} + \text{OUTFLOW} = \frac{2S \text{ Ac. Ft. (24 HRS./DAY)}}{(1.98 \frac{\text{Ac. Ft.}}{\text{cfs DAY}})(0.03333 \text{ hrs})} + O(\text{cfs})$

$\frac{2S}{\Delta t} + O = 727.27\,S + O$ cfs

ELEVATION	S Ac.-Ft.	O c.f.s.	$\frac{2S}{\Delta t} + O$ c.f.s.
533.0	0	0	0
534.0	0.022	4.13	20.13
535.0	0.064 *	11.67	58.22
536.0	0.138	21.43	121.79
537.0	0.228 *	31.40	197.22
538.0	0.320	37.16	269.89
538.5	0.378	39.72	314.63

* FROM DEPTH STORAGE CURVE (EXHIBIT "H")

EXHIBIT "E"
SHT. 1 OF 1

Design Pond Routing

FORM 102	0	1	2	3	4	5	6	7
Line	Time	I_1	I_1+I_2	$\frac{2S_1}{\Delta t} - O_1$	$\frac{2S_2}{t} + O_2$	Elev	Outflow O_2	Storage S_2
1	0	0	0		0		0	
2	2	9.68	9.68	0	9.68		1.9	
3	4	19.36	29.04	5.88	34.92		7.0	
4	6	29.04	48.40	20.92	69.32		13.5	
5	8	38.72	67.76	42.32	110.08		20.0	
6	10	48.40	87.12	70.08	157.20		26.4	
7	12	48.40	96.80	104.40	201.20		31.7	
8	14	48.40	96.80	137.80	234.60		34.9	
9	16	48.40	96.80	164.80	261.60		36.7	
10	18	48.40	96.80	188.20	285.00		38.2	
11	20	48.40	96.80	208.60	305.40		39.2	
12	22	38.72	87.12	227.00	314.12	538.50	39.7	0.378 Ac.-Ft. 16,466 Cu.Ft. ← PEAK OUTFLOW
13	24	29.04	67.76	234.72	302.48		39.1	
14	26	19.36	48.40	224.28	272.68		37.5	
15	28	9.68	29.04	197.68	226.72		34.20	

EXHIBIT "F"
SHT. 1 OF 2

Design Pond Routing

FORM 102	0	1	2	3	4	5	6	7
Line	Time	I_1	I_1+I_2	$\frac{2S_1}{\Delta t} - O_1$	$\frac{2S_2}{t} + O_2$	Elev	Outflow O_2	Storage S_2
15	CONTINUED 28	9.68	29.04	197.68	226.72		34.20	
16	30	0	9.68	158.32	168.00		27.8	
17	32	0	0	112.40	112.40		20.2	
18	34	0	0	72.00	72.00		13.9	
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EXHIBIT "F"
SHT. 2 OF 2

OVERFLOW STRUCTURE CALCULATIONS

1) REQUIRED DESIGN STORM FOR OVERFLOW STRUCTURE IS 100 YEAR / 20 MINUTE :

INFLOW $Q_{100/20}$ = 54.78 cfs (EXHIBIT "B" SHT. 2 OF 4)

2) STRUCTURE WILL BE AN AREA INLET (DOUBLE)

$Q = CLH^{3/2}$ (ASSUME OUTFLOW OPENING BLOCKED)

$Q = 54.78$ cfs

$C = 3.0$

$L = 11.67$ Ft. (2 SIDES @ 3.17' AND 2 SIDES @ 6.25')

FIND H :

$H^{3/2} = Q/CL$

$H^{3/2} = 54.78/3.0(18.84)$

$H^{3/2} = 0.969$

$H = 0.98'$ (11.76") OPENING

ELEVATION HIGH WATER 25 YR. STORM	538.50
ELEVATION HIGH WATER 100 YR. STORM	539.48
ELEVATION TOP OF STRUCTURE SILL	538.50
ELEVATION TOP OF BERM	540.5
ELEVATION HIGH WATER 15 YR STORM (APPROX. VALUE H.W. TO BE USED ON HYD. CALC's.)	537.9 ±

EXHIBIT "G"
SHT. 1 OF 1

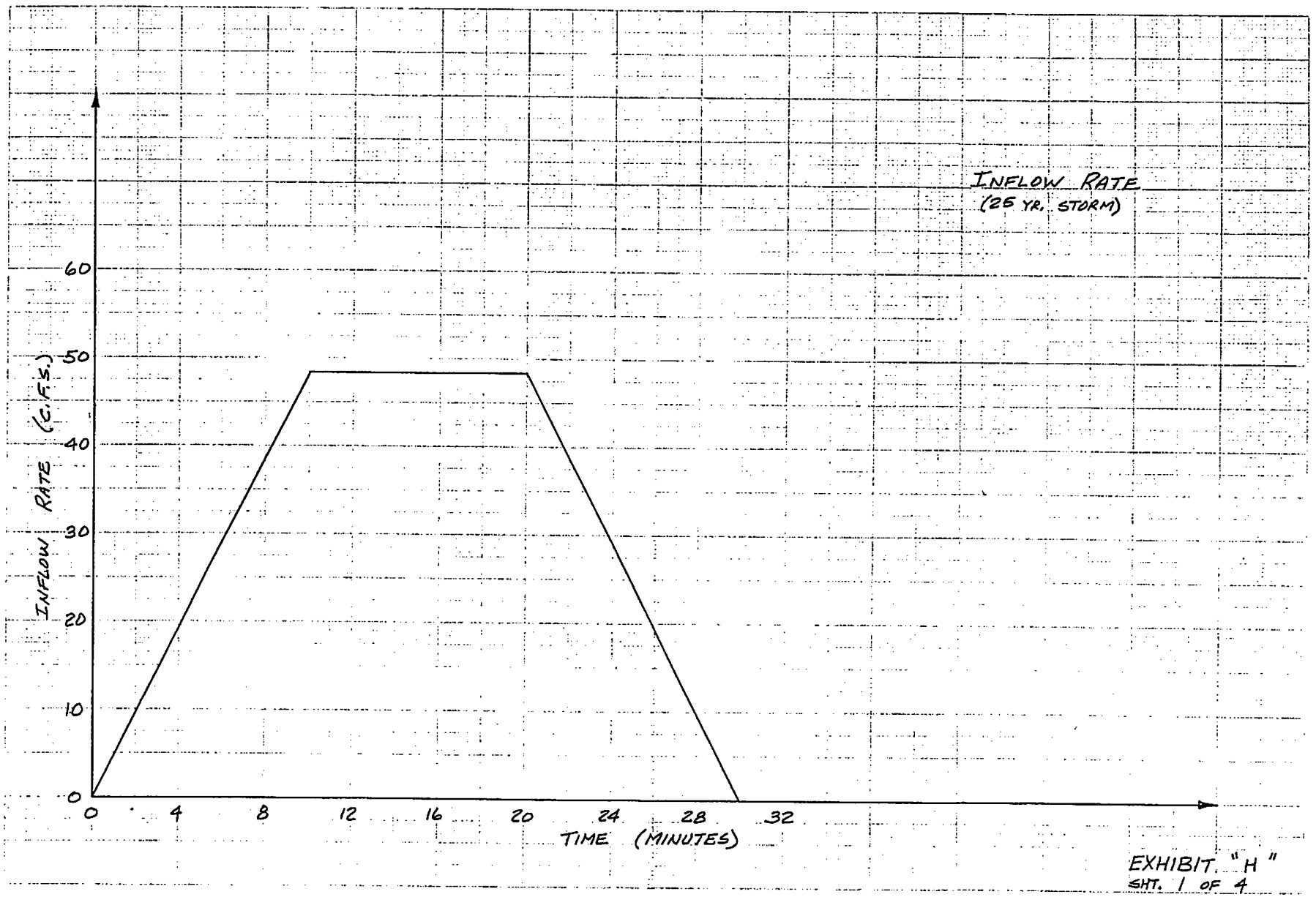


EXHIBIT "H"
SHT. 1 OF 4

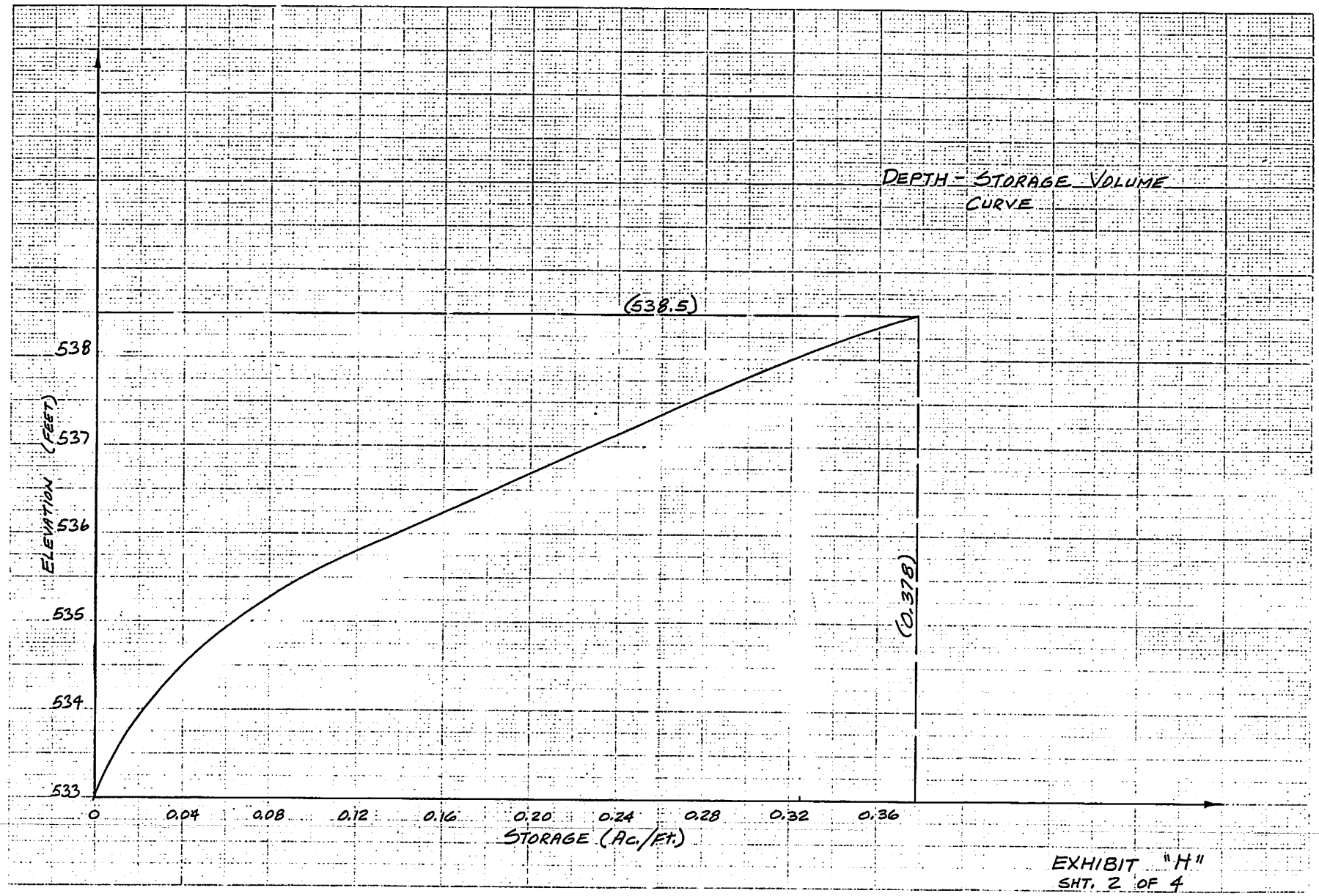


EXHIBIT "H"
SHT. 2 OF 4

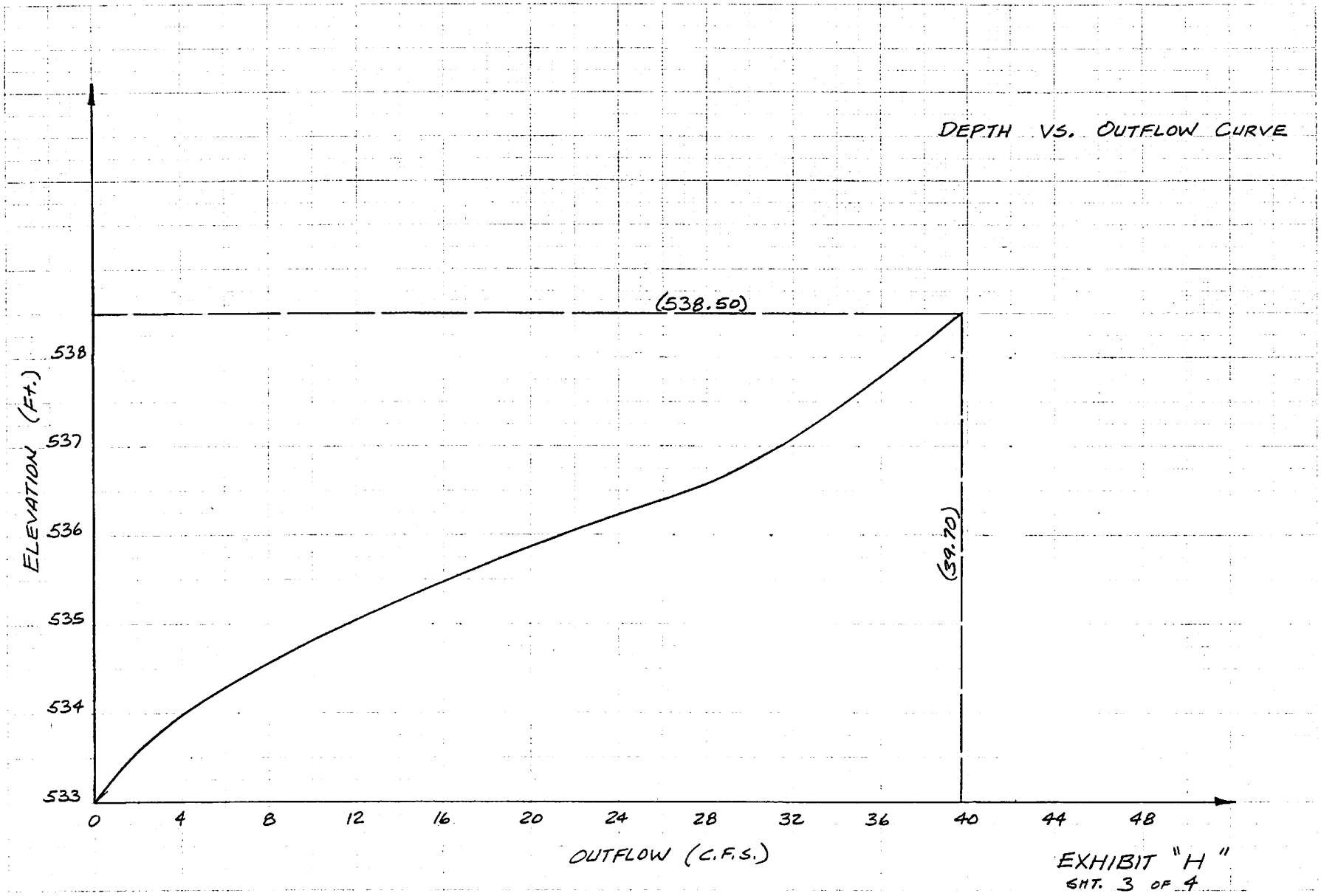


EXHIBIT "H"
SHT. 3 OF 4

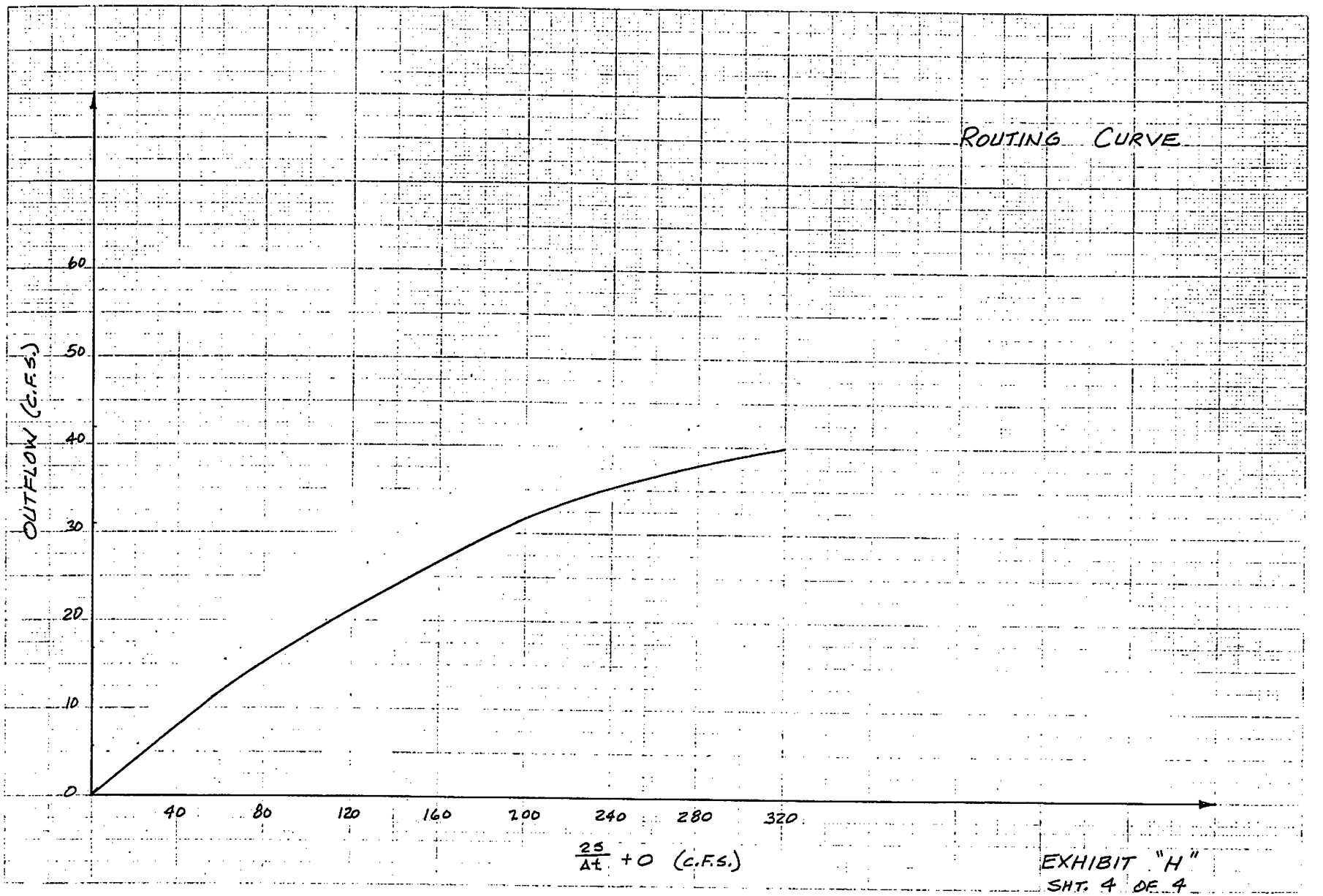


EXHIBIT "H"
SHT. 4 OF 4

CORONATION ESTATES

OVERFLOW STRUCTURE CALCULATIONS

1) REQUIRED DESIGN STORM FOR OVERFLOW STRUCTURE IS 100 YEAR / 20 MINUTE :

INFLOW $Q_{100/20}$ = 54.78 cfs (EXHIBIT "B" SHT. 2 OF 4)

2) STRUCTURE WILL BE AN AREA INLET (DOUBLE)

$Q = C L H^{3/2}$ (ASSUME OUTFLOW OPENING BLOCKED)

Q = 54.78 cfs

C = 3.0

L = 11.67 Ft. (2 SIDES @ 3.17' AND 2 SIDES @ 6.25')

FIND H :

$H^{3/2} = Q/CL$

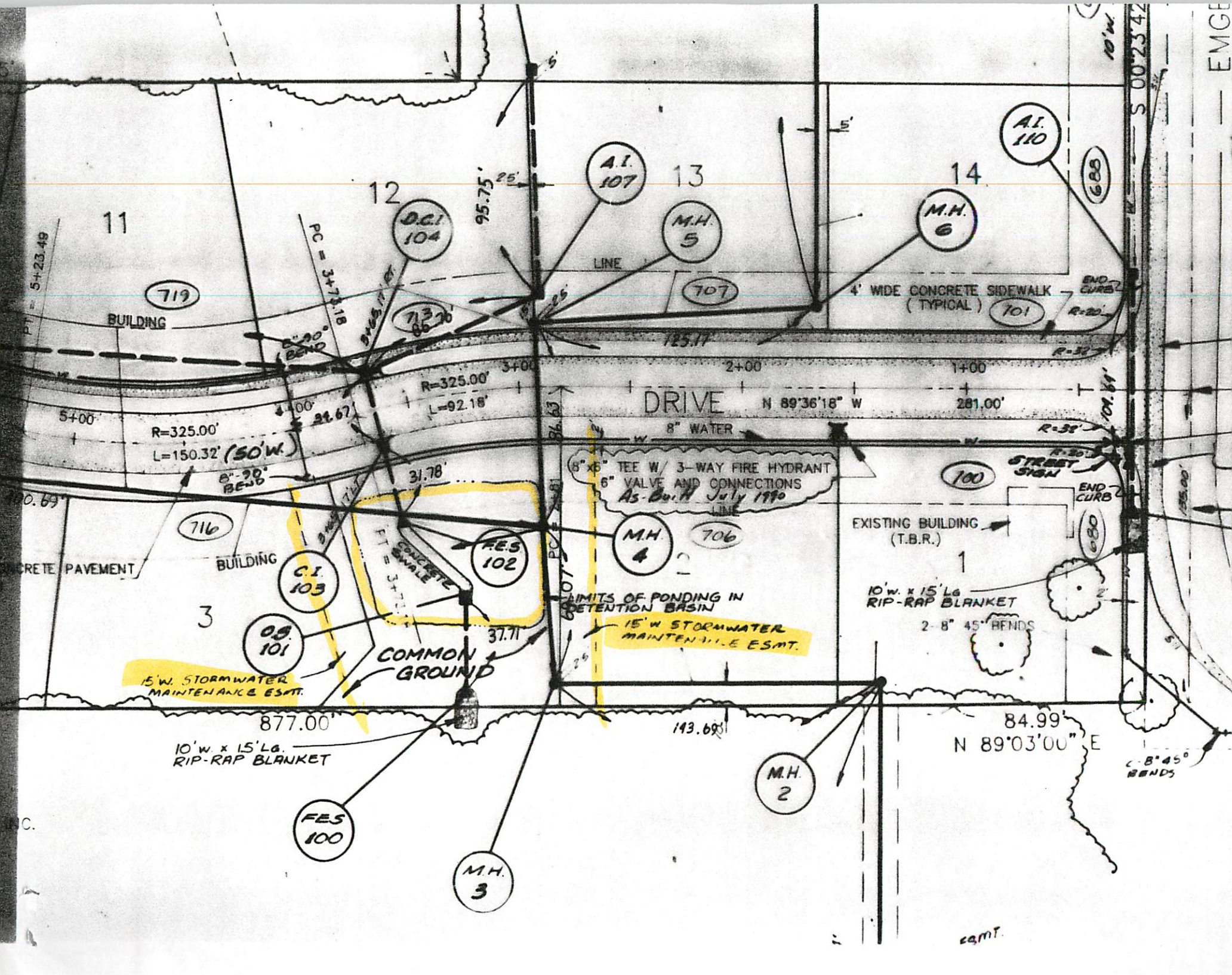
$H^{3/2} = 54.78 / 3.0(18.84)$

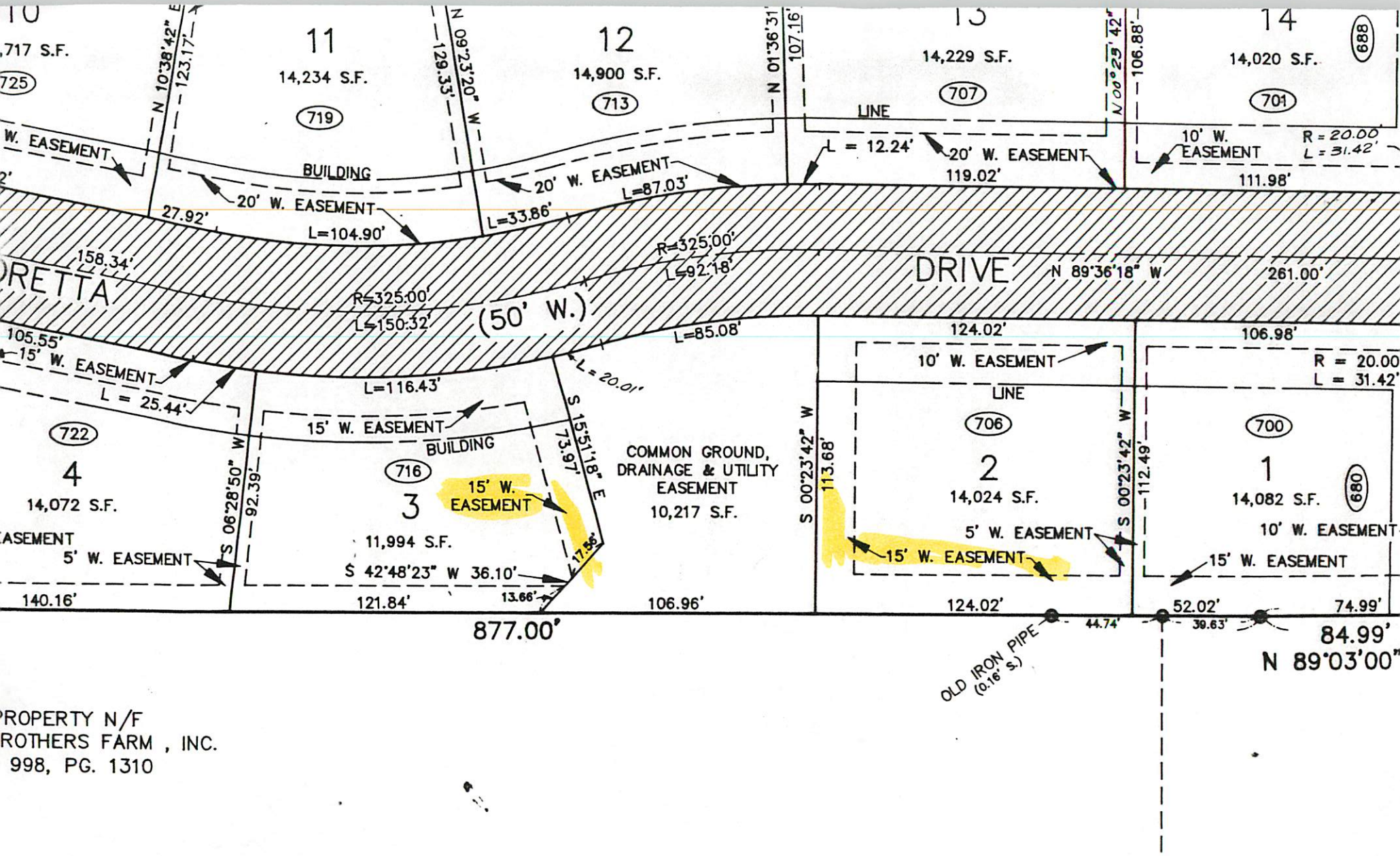
$H^{3/2} = 0.969$

H = 0.98' (11.76") OPENING

ELEVATION HIGH WATER 25 YR. STORM	538.50
ELEVATION HIGH WATER 100 YR. STORM	539.48
ELEVATION TOP OF STRUCTURE SILL	538.50
ELEVATION TOP OF BERM	540.5
ELEVATION HIGH WATER 15 YR STORM (APPROX. VALUE H.W. TO BE USED ON HYD. CALC'S.)	537.9 ±

EXHIBIT "G"
SHT. 1 OF 1


11
12
13
14
A.I. 107
A.I. 110
O.C.I. 104
M.H. 5
M.H. 6
688
719
707
716
706
100
101
BUILDING
LINE
4' WIDE CONCRETE SIDEWALK (TYPICAL)
END CURB
STREET SIGN
DRIVE
N 89°36'18" W
281.00'
8" WATER
125.11'
95.75'
R=325.00'
L=92.18'
R=325.00'
L=150.32'
(50'W.)
8"x6" TEE W/ 3-WAY FIRE HYDRANT
6" VALVE AND CONNECTIONS
As-Built July 1990
EXISTING BUILDING (T.B.R.)
M.H. 4
M.H. 2
M.H. 3
C.I. 103
F.E.S. 102
F.E.S. 100
O.S. 101
CONCRETE SWALE
LIMITS OF PONDING IN DETENTION BASIN
15'W STORMWATER MAINTENANCE ESMT.
COMMON GROUND
10'W. x 15'Lg. RIP-RAP BLANKET
2-8" 45° BENDS
877.00'
84.99'
N 89°03'00" E
193.69'
31.78'
31.71'
CONCRETE PAVEMENT
3
1
2



PROPERTY N/F
ROTHERS FARM , INC.
998, PG. 1310

THIS PLA