**MOEHRING & ASSOCIATES** — CONSULTING ENGINEERS

DRAINAGE PLAN
AND
SUPPORTING CALCULATIONS

# SUNRIDGE ADDITION

AND

# TEAL BROOK ADDITION

## WICHITA, SEDGWICK COUNTY, KANSAS

1. Need design information on Channel to the North and the two structures across the streets.
✓ 2 Need information on Lake design - elev. & side slope etc..
3 What is the existing pre-development peak?

PREPARED BY

MOEHRING & ASSOCIATES
CONSULTING ENGINEERS

AND

M. S. MITCHELL
FLOOD PLAIN MANAGEMENT SPECIALIST

JULY 26, 1988

433 S. HYDRAULIC — WICHITA, KANSAS 67211 — 263-8291

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## PREFACE

Attached hereto are the computations for the referenced drainage plan.

The publication "Interim Drainage and Storm Sewer Policy for Design Criteria and Documentations, City of Wichita," revised 7/1/87, was used as a guide for the hydrologic and hydraulic computations. This publication is hereinafter referred to as the "Policy Manual".

Manual #1, as referenced therein, refers to "Design of Urban Highway Drainage - The State of the Art", by Reitz & Jens, Inc., April, 1980. Manual #2 refers to "Drainage of Highway Pavements, Hydraulic Engineering Circular #12", by Tye Engineering, Inc., March, 1984.

## HYDROLOGY METHODS

The rational method was used for hydrologic analysis. Runoff coefficients were based on the table provided in Attachment D, of the "Policy Manual".

The time of concentration for overland flow was determined by either the velocities given in Attachment E, of the "Policy Manual" or by the Kinematic Wave Theory, as presented in Section 4.1.3, of Manual #2. Time of travel in street gutters was determined by the method used in Section 4.1.3, of Manual #2. The minimum time of concentration for design purposes was taken to be 15 minutes.

The two-year return period storm was used as the basis of design, per Table 1 of the "Policy Manual". Also, a check was made that the 100-year runoff was confined to the right-of-way.

## HYDRAULIC DESIGN

For each inlet, street flooding and inlet capacity was checked for the minor storm. Conveyance in the street was based on the modified Manning Equation:

$$Q = 0.56/n(S_x)^{5/3}(T)^{8/3} \; S^{1/2} \qquad \text{(Eq. 4, Manual \#2)}$$

It is assumed that $t_c$, for street flow, was equal to $t_c$, for pipe flow. This should be a conservative assumption.

For local streets, curb-deep flow is tolerable for the minor storm. For collectors, a single eight-foot center lane should remain unflooded for the minor storm.

Inlet capacities were determined by the methods presented in Manual #2, using charts 9, 10 and 12. Carryover flows were added to the next inlet downstream.

In this analysis, City of Wichita Type 1A Inlets, 3/8 in/ft street cross-slope, and 6-5/8 Std. curb and gutter were assumed to be utilized.

Pipe systems were designed using the calculated capacity of each inlet, on the basis of a two-year storm.

Preliminary pipe sizes were estimated and tabulated under "Conduit Data". Manning's Equation was used to calculate friction losses in pipes flowing full. Minor losses are accounted for using conservation of momentum principles. It is desirable to keep the hydraulic grade line approximately 6 inches below the curb flowline elevations.

## MAJOR STORM OVERFLOW

For each sub-area, a check was made for conveyance capacity of the major storm. To simplify analysis, the following assumptions were made:

1. The time of concentration is identical for both the major and minor storm. Thus, a ratio of rainfall intensities is used to determine $Q_{100}$ @ each point.

2. The pipe system capacity during the major storm is assumed to be the same as during the minor storm. This is a conservative assumption, because increased ponding depths during the major storm event will increase the available head on the inlet/pipe system, thus increasing the capacity.

3. The conveyance capacity of the street R/W's was calculated for several gradients, and used as a check against tabulated discharges for the 100 yr. event.

In general, the minimum grade at the right-of-way line is 0.3' above the top of the curb. If walk grades higher than minimum are required to confine the major storm overflow, such walk elevations will be noted and identified.

SUNRIDGE - TEAL BROOK ADD'N - System 100

HYDROLOGY DATA COMPILATION - for

DRAINAGE CONCEPT

A. INITIAL DATA -

1. Drainage Areas -

Parcel a/ Sunridge Add'n = 23.01 Ac.

Parcel b/ Teal Brook Add'n = 36.28 Ac.

Parcel c/ Offsite - N. of 21st St. - Part of Cedar Downs Add'n = 55 Ac.

Parcel d/ Offsite - Proposed L.C. site at S.W. corner of Intersection 21st & 119th = 2.51 Ac.

Parcel e/ Offsite - Existing Residential tract on West side of 119th St. = 2.07 Ac.

2. S.C.S. Hydrologic Soil Group & Runoff Coefficients

From S.C.S. Soil Survey Maps, for Sedgwick County, all soils within the above listed drainage areas, are identified as Va, Vb and Vc; Vanoss soils, which are in the Hydrologic Soil Group "B".

| Parcel/Area | Present CN | Future Ac./D.U. | Future CN | Future % Imperv. | Future "$C_2$" | Future "$C_{100}$" |
|---|---|---|---|---|---|---|
| a/=23.01 | 71 | 0.28 | 74 | 38% | 0.44 | 0.61 |
| b/=38.79 | 71 | 0.42 | 72 | 27% | 0.37 | 0.55 |
| c/=55.0 | 68 | 1.0 | 68 | 20% | 0.33 | 0.51 |
| d/= 2.51 | 71 | L.C. | 92 | 90% | 0.80 | 0.93 |
| e/= 2.07 | 68 | 0.33 | 72 | 30% | 0.39 | 0.57 |
| Σ 121.38 | ≈ 70 | | | | | |

Note: The preceding "CN's" were determined from Table 2-2 of TR 55; and the Rational "C" values were taken from Attachment "D" of City of Wichita Interim Drainage Policy.

The "CN"'s will be utilized in the development of Inflow Hydrograph for Flood Routing thru the detention pond(s).

$q = 2.8''$

$= \frac{2.8}{12} \times 121.38$

$= 28.3$ Ac-ft

The Rational "C" factors will be utilized with the Rational Method for determination of flow in streets to inlets and design of storm sewers.

Future development of Parcel d/ (the 2.51 Ac. Exception) will as previously stated, be Light Commercial. As such, it will not be allowed to discharge storm runoff through the adjacent residential lots. Some "on site" detention might likely be developed in parking lots, etc., and discharged thru a system of conduits into the South ditch of 21st Street, and flow approximately 1100 to 1200 feet West, joining the contribution from the 55 acre offsite basin North of 21st Street. The time of concentration, and thus the storm runoff at that point, will be governed by the 55 acre offsite drainage area.

Parcel e/ (2.07 Ac. Exception) is projected as future development into approximately 6 single family lots with a cul-de-sac as access to 119th St. West. As such, only the rear half of lots situated in the West half of Parcel e/ could be anticipated to discharge toward the Sunridge parcel, and that contributing area has been estimated as 0.69 Ac., and will be incorporated in peak discharge computations.

B. HYDROLOGY

Use Rational Method, Q = CIA

1. Determine "C" Factors for Sub-Basins, System 100

| Node | Soil Type | Land Use | $C_2$ | $C_{100}$ |
|---|---|---|---|---|
| 110 | B | Res.- 1/4 Ac. | 0.44 | 0.61 |
| 109 | B | " | 0.44 | 0.61 |
| 108 | B | " | 0.44 | 0.61 |
| 107 | B | " | 0.44 | 0.61 |
| 106 | B | " | 0.44 | 0.61 |
| 105 | B | " | 0.44 | 0.61 |
| 104 | B | " | 0.44 | 0.61 |
| 103 | B | Res.- 2/5 Ac. | 0.37 | 0.55 |
| 102 | B | " | 0.37 | 0.55 |
| 101 | End of System | | | |

2. Determine $T_c$ and I for Sub-Basin contributing to each Node

| Node | $T_c$ | $I_2$ | $I_{100}$ |
|---|---|---|---|
| 110 | $t_o$ = 21.0 min.<br>$t_g$ = 0.9 min.<br>$T_c$ = 21.9 min. | 3.18 | 6.27 |
| 109 | 15 | 3.83 | 7.37 |
| 108 | $t_o$ = 21.0 min.<br>$t_g$ = 0.67 min.<br>$T_c$ = 21.67 min. | 3.20 | 6.20 |
| 107 | $t_o$ = 7.0 min.<br>$t_g$ = 6.37 min.<br>$T_c$ = 13.37 min. | 3.83 | 7.37 |
| 106 | 15 | 3.83 | 7.37 |
| 105 | 15 | 3.83 | 7.37 |
| 104 | $t_o = T_c = 20$ | 3.33 | 6.53 |
| 103 | 15 | 3.83 | 7.37 |
| 102 | 15 | 3.83 | 7.37 |
| 101 | End of System | | |

3. Determine Area, "A", of Sub-Basins contributing to each Node.

| Node | Area (Acres) | | |
|---|---|---|---|
| 110 | 2.94 + 0.06 + 0.15 + 0.35 + 0.04 + 0.12 + 0.41 + 0.43 | = | 4.50 Ac. |
| 109 | 0.12 + 0.40 + 0.43 + 0.70 + 0.02 | = | 1.67 Ac. |
| 108 | 2.13 + 1.55 + 0.03 | = | 3.71 Ac. |
| 107 | 1.60 + 0.43 + 0.32 + 1.41 + 0.01 | = | 3.77 Ac. |
| 106 | 0.98 + 0.37 + 0.03 + 0.12 | = | 1.44 Ac. |
| 105 | 0.43 + 0.43 + 0.37 + 0.34 + 0.09 + 0.18 + 0.72 + 0.18 + 0.44 + 0.38 | = | 3.56 Ac. |
| 104 | 0.06 + 0.04 + 0.10 + 0.13 + 0.84 + 0.15 + 1.02 + 0.57 + 0.15 + 0.09 | = | 3.15 Ac. |
| 103 | 0.68 + 0.60 + 0.67 + 0.58 + 0.66 + 0.79 + 0.25 | = | 4.23 Ac. |
| 102 | 1.0 + 0.34 + 0.36 | = | 1.70 Ac. |
| 101 | End of System | | |

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Summation of Contributing D.A.'s to Nodes

110 + 109 to 104 = 6.17 Ac.

108 to 107 = 3.71 Ac.

108 + 107 to 106 = 7.48 Ac.

108 + 107 + 106 to 105 = 8.92 Ac.

108 + 107 + 106 + 105 to 104 = 12.48 Ac.

To 104 = 12.48 + 6.17 = 18.65 Ac. in conduit
+ overland to 104 = 3.15
Total to 104 = 21.80 Ac. = 104 to 103

103 to 102 = 21.80 + 4.23 = 26.03 Ac.

102 to 101 = 26.03 + 1.70 = 27.73 Ac. = Discharge to Pond #1

4. Determine Surface Contributions ($Q_2$), to each Node

| Node | $C_2$ | $I_2$ | A | $Q_2$ |
|---|---|---|---|---|
| 110 | 0.44 | 3.18 | 4.50 | 6.30 cfs |
| 109 | 0.44 | 3.83 | 1.67 | 2.81 cfs |
| 108 | 0.44 | 3.20 | 3.71 | 5.22 cfs |
| 107 | 0.44 | 3.83 | 3.77 | 6.35 cfs |
| 106 | 0.44 | 3.83 | 1.44 | 2.43 cfs |
| 105 | 0.44 | 3.83 | 3.56 | 6.00 cfs |
| 104 | 0.44 | 3.33 | 3.15 | 4.62 cfs |
| 103 | 0.37 | 3.83 | 4.23 | 5.99 cfs |
| 102 | 0.37 | 3.83 | 1.70 | 2.41 cfs |
| 101 | (End System) | | | |

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5. Determine Surface Contribution ($Q_{100}$) to each Node

| Node | $C_{100}$ | $I_{100}$ | A | $Q_{100}$ |
|---|---|---|---|---|
| 110 | 0.61 | 6.27 | 4.50 | 17.21 cfs |
| 109 | 0.61 | 7.37 | 1.67 | 7.51 cfs |
| 108 | 0.61 | 6.30 | 3.71 | 14.26 cfs |
| 107 | 0.61 | 7.37 | 3.77 | 16.95 cfs |
| 106 | 0.61 | 7.37 | 1.44 | 6.47 cfs |
| 105 | 0.61 | 7.37 | 3.56 | 16.00 cfs |
| 104 | 0.61 | 6.53 | 3.15 | 12.55 cfs |
| 103 | 0.55 | 7.37 | 4.23 | 17.15 cfs |
| 102 | 0.55 | 7.37 | 1.70 | 6.89 cfs |
| 101 | (End of System) | | | |

6. Flood Routing/Inlet Sizing - 2 Yr. Design Storm

| Node | Inlet Condition | Inlet Length | $Q_2$ * Approach | $Q_2$ # Intercept | $Q_2$ By-Pass | By Pass To Node |
|---|---|---|---|---|---|---|
| 110 | Sump | 5 | 6.30 | 6.30 | 0 | - |
| 109 | Sump | 5 | 2.81 | 2.81 | 0 | - |
| 108 | Sump | 5 | 5.22 | 5.22 | 0 | - |
| 107 | Sump | 5 | 6.35 | 6.35 | 0 | - |
| 106 | Sump | 5 | 2.43 | 2.43 | 0 | - |
| 105 | Sump | 5 | 6.00 | 6.00 | 0 | - |
| 104 | Sump | Area Inlet | 4.62 | 4.62 | 0 | - |
| 103 | Sump | 5 | 5.99 | 5.99 | 0 | - |
| 102 | Sump | 5 | 2.41 | 2.41 | 0 | - |
| 101 | (End of System) | | | | | |

* Q approach = $Q_2$ + Q By Pass from upstream Node

# Q intercept = Q input into pipe system

Configuration of Sunridge Addition, and the site topography create two principal sump areas. The discharge of surface runoff for the 2 yr. storm, is conveyed thru storm sewers, located in drainage easements, to a point of discharge into detention pond #1. To prevent the necessity of overland channels, investigate the capability of Storm Sewer System 100, to convey the 100 yr. runoff.

Therefore, a flood routing/inlet sizing evaluation will be made, as well as the evaluation of 100 yr. containment within the street R/W's.

Subsequently, an evaluation of System Hydrology, including Conduit Data will be made for the 100 yr. Storm Frequency, thru System 100.

Flood Routing/Inlet Sizing - 100 yr. Design Storm

| Node | Inlet Condition | Inlet Length | $Q_{100}$ * Approach | $Q_{100}$ Intercept | $Q_{100}$ By-Pass across st. | By-Pass to Node |
|---|---|---|---|---|---|---|
| 110 | Sump | 5 | 17.21 | 9.5 | 7.71 | 109 |
| 109 | Sump | 10 | 7.71+7.51 = 15.22 | 15.22 | 0 | - |
| 108 | Sump | 5 | 14.26 | 9.5 | 4.76 | 106 |
| 107 | Sump | 10 | 16.95 | 16.95 | 0 | - |
| 106 | Sump | 5 | 6.47+4.76 = 11.23 | 10.10 | 1.13 | 105 |
| 105 | Sump | 10 | 16.0+1.13 = 17.13 | 17.13 | 0 | - |
| 104 | Sump | Area Inlet | 12.55 | 12.55 | 0 | - |
| 103 | Sump | 10 | 17.15 | 17.15 | 0 | - |
| 102 | Sump | 5 | 6.89 | 6.89 | 0 | - |
| 102 | (End of System) | | | | | |

7. Street Flow Depths - 2 Yr. Design Storm

| Node | $Q_2$ Approach | Flow Distribution | Street Slope (%) | Flow Depth | Allowable Depth | Comment |
|---|---|---|---|---|---|---|
| 110 | 6.30 | 80% (N) = 5.04 | 0.35 | 0.39 | 0.55 | OK |
| | | 20% (E) = 1.26 | 1.00 | 0.19 | 0.55 | OK |
| 109 | 2.81 | 55% (N) = 1.55 | 0.35 | 0.25 | 0.55 | OK |
| | | 45% (E) = 1.26 | 1.00 | 0.19 | 0.55 | OK |
| 108 | 5.22 | 58% (N) = 3.03 | 0.34 | 0.31 | 0.55 | OK |
| | | 42% (E) = 2.19 | 0.70 | 0.25 | 0.55 | OK |
| 107 | 6.35 | 10% (N) = 5.71 | 0.34 | 0.44 | 0.55 | OK |
| | | 90% (E) = 0.64 | 0.70 | 0.16 | 0.55 | OK |
| 106 | 2.43 | 4% (S) = 0.10 | 1.00 | 0.09 | 0.55 | OK |
| | | 96% (E) = 2.33 | 0.73 | 0.25 | 0.55 | OK |
| 105 | 6.00 | 2% (S) = 0.12 | 0.66 | 0.09 | 0.55 | OK |
| | | 98% (E) = 5.88 | 0.73 | 0.38 | 0.55 | OK |
| 103 | 5.99 | 54% (S) = 3.24 | 0.40 | 0.30 | 0.30 | OK |
| | | 46% (N) = 2.75 | 0.40 | 0.29 | 0.30 | OK |
| 102 | 2.41 | 46% (N) = 1.11 | 0.40 | 0.09 | 0.30 | OK |
| | | 54% (S) = 1.30 | 0.40 | 0.09 | 0.30 | OK |
| 101 | (End of System) | | | | | |

SUNRIDGE - TEAL BROOK HYDROLOGY - SYSTEM 100 - 2 Yr. Frequency

| SURFACE TRIBUTARY AREA | | | | | | HYDROLOGY SUMMATION | | | | CONDUIT DATA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Node to Node | "C" | Area Ac. | $T_c$ Min. | $I_2$ | $Q_2$ cfs | $T_c$ Min. | $I_2$ | $Q_2$ cfs | $\Sigma Q_2$ | Pipe Size | Vel. fps | Length | T.T. | T.T. + $T_c$ |
| 110 - 109 | .44 | 4.50 | 21.9 | 3.18 | 6.30 | 21.9 | 3.18 | 6.30 | 6.30 | 18" | 3.57 | 40 | 0.19 | 22.09 |
| 109 - 104 | .44 | 1.67 | 15 | 3.83 | 2.81 | 22.09 | 3.16 | 2.32 | 8.62 | 24" | 2.74 | 215 | 1.31 | 23.40 |
| 108 - 107 | .44 | 3.71 | 21.67 | 3.20 | 5.22 | 21.67 | 3.20 | 5.22 | 5.22 | 18" | 2.95 | 40 | 0.23 | 21.90 |
| 107 - 106 | .44 | 3.77 | 15 | 3.83 | 6.35 | 21.90 | 3.18 | 5.28 | 10.50 | 24" | 3.34 | 215 | 1.07 | 22.97 |
| 106 - 105 | .44 | 1.44 | 15 | 3.83 | 2.43 | 22.97 | 3.10 | 1.96 | 12.46 | 30" | 2.54 | 40 | 0.26 | 23.23 |
| 105 - 104 | .44 | 3.56 | 15 | 3.83 | 6.00 | 23.23 | 3.08 | 4.82 | 17.28 | 30" | 3.52 | 225 | 1.06 | 24.29 |
| 104 - 103 | .44 | 3.15 | 20 | 3.33 | 4.62 | 24.29 | 3.01 | 4.17 | 30.07 | 42" | 3.13 | 160 | 0.85 | 25.14 |
| 103 - 102 | .37 | 4.23 | 15 | 3.83 | 5.99 | 25.14 | 2.95 | 4.62 | 34.69 | 48" | 2.76 | 40 | 0.24 | 25.38 |
| 102 - 101 | .37 | 1.70 | 15 | 3.83 | 2.41 | 25.38 | 2.94 | 1.85 | 36.54 | 48" | 2.91 | 180 | 1.03 | 26.41 |

City of Wichita minimum construction slopes to produce V = 2 fps @ flow depth = 0.2 x diam.

18" = 0.30%
24" = 0.20%
30" = 0.15%
36" = 0.12%
42" = 0.10%
48" = 0.08%

)0 - 100 YR. FREQUENCY

| | INLET SIZE & CAPACITY | | | | CONDUIT DATA | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Inlet Length | $Q_{100}$ Intercept | $Q_{100}$ By-Pass | $\Sigma Q_{100}$ Pipe | Pipe Size | Velocity fps | Length | T.T | T.T.+ T.C. |
| 5 | 9.5 | 7.71 to 109 | 9.51 | 18" | 5.38 | 40 | 0.12 | 22.02 |
| 10 | 14.09 | 0 | 23.60 | 24" | 7.51 | 215 | 0.48 | 22.50 |
| 5 | 9.5 | 4.76 to 106 | 9.5 | 18" | 5.38 | 40 | 0.12 | 21.79 |
| 10 | 14.44 | 0 | 23.94 | 24" | 7.62 | 215 | 0.47 | 22.26 |
| 5 | 9.5 | 0.73 to 105 | 33.44 | 30" | 6.81 | 40 | 0.10 | 22.36 |
| 10 | 14.22 | 0 | 47.66 | 30" | 9.70 | 215 | 0.37 | 22.73 |
| Area Inlet | 11.86 | 0 | 83.12 | 42" | 8.64 | 160 | 0.31 | 23.04 |
| 10 | 14.26 | 0 | 97.38 | 48" | 7.75 | 40 | 0.09 | 23.13 |
| 5 | 5.71 | 0 | 103.09 | 48" | 8.20 | 180 | 0.37 | 23.50 |

STRUCTURE HEAD LOSS COMPUTATIONS - SYSTEM 100

Structure 110 - Curb Inlet - $Q_o$ only

$Q_o$ = 6.30 cfs; $D_o$ = 18"; $V_o$ = 3.57 fps; $V_o^2/2g$ = 0.1979

To generate initial velocity, $H_v = V_o^2/2g$ = 0.20

+ entrance loss into 18" pipe, $H_e = 0.5 \times V_o^2/2g$ = 0.10

Total Structure Head Loss = 0.20 + 0.10 = 0.30'

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Structure 109 - Curb Inlet + Upstream Flow

$Q_u$ = 6.30 cfs; $V_u$ = 3.57 fps; $V_u^2/2g$ = 0.1979

$Q_g$ = 2.32 cfs

$Q_o$ = 8.62 cfs; $V_o$ = 2.74 fps; $V_o^2/2g$ = .1166

$H_u - H_o = V_o^2/2g = Q_u/Q_o\ (V_u^2/2g)$

$H_u - H_o$ = .1166 - (6.30/8.62 x 0.1979)

$H_u - H_o$ = .1166 - .1446 = - .03'

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Structure 108 - Curb Inlet - $Q_o$ only

$Q_o$ = 5.22 cfs; $D_o$ = 18"; $V_o$ = 2.85 fps; $V_o^2/2g$ = 0.1351

To generate initial velocity, $H_v = V_o^2/2g$ = 0.14

+ entrance loss into 18" pipe, $H_e = 0.5 \times V_o^2/2g$ = 0.07

Total structure Head Loss = 0.14 + 0.07 = 0.21'

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Structure 107 - Curb Inlet + Lateral Flow

$Q_e$ = 5.22 cfs; $Q_g$ = 6.35 cfs; $Q_o$ = 11.57 cfs; $D_o$ = 24"

$V_e$ = 2.95 fps; $V_e^2/2g$ = .1351; $V_o$ = 3.34 fps; $V_o^2/2g$ = .1732

$H_e - H_o = V_o^2/2g - Q_e/Q_o\ (0.3\ V_e^2/2g)$

$H_e - H_o = 0.1732 - (0.4512 \times 0.0405)$

$H_e - H_o = 0.1732 - 0.0183 = 0.16"$

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Structure 106 - Curb Inlet + Lateral Flow

$Q_e$ = 11.57 cfs; $Q_g$ = 2.43; $Q_o$ = 14.0 cfs; $D_o$ = 30"

$V_e$ = 2.95 fps; $V_e^2/2g$ = .1732; $V_o$ = 2.54 fps; $V_o^2/2g$ = .1002

$H_e - H_o = V_o^2/2g - Q_e/Q_o\ (.03\ V_e^2/2g)$

$H_e - H_o = .1002 - (0.8264 \times 0.0520)$

$H_e - H_o = 0.06'$

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Structure 105 - Curb Inlet + Upstream Flow

$Q_u$ = 14.0 cfs; $V_u$ = 2.54 fps; $V_u^2/2g$ = 0.1002

$Q_g$ = 6.0 cfs

$Q_o$ = 20 cfs; $V_o$ = 3.52 fps; $V_o^2/2g$ = 0.1924

$H_u - H_o = V_o^2/2g - Q_u/Q_o\ (V_u^2/2g)$

$H_u - H_o = 0.1924 - (0.7 \times 0.1002)$

$H_u - H_o = 0.1924 - 0.0701 = 0.12'$

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Structure 104 - Area Inlet + Lateral Flow + Lateral Flow

$Q_e$ = 8.62 cfs; $Q_e$ = 17.28 cfs; $Q_i$ = 4.17 cfs

$Q_o$ = 30.07 cfs

$V_e$ = 3.52 fps; $V_e^2/2g$ = 0.1924

$V_e$ = 2.74 fps; $V_e^2/2g$ = 0.1166

$V_o$ = 3.13 fps; $V_o^2/2g$ = 0.1521

$H_e - H_o = V_o^2/2g - [Q_e/Q_o\ (0.3\ V_e^2/2g)] - [Q_e/Q_o\ (0.3\ V_e^2/2g)]$

$H_e - H_o = 0.1521 - (.2867 \times .1924) - (0.5747 \times 0.0350)$

$H_e - H_o = 0.1521 - 0.0552 - 0.0201$

$H_e - H_o = 0.08'$

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Structure 103 - Curb Inlet + Upstream Flow

$Q_u$ = 30.07 cfs; $V_u$ = 3.13 fsp; $V_u^2/2g$ = 0.1521

$Q_g$ = 4.62 cfs

$Q_o$ = 34.69 cfs; $V_o$ = 2.76; $V_o^2/2g$ = 0.1183

$H_u - H_o = V_o^2/2g - Q_u/Q_o\ (V_u^2/2g)$

$H_u - H_o = 0.1183 - (0.8668 \times 0.1521)$

$H_u = H_o = 0.1183 - 0.1318 = -0.01'$

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Structure 102 - Curb Inlet + Upstream Flow

$Q_u$ = 34.69 cfs; $V_u$ = 2.76 fps; $V_u^2/2g$ = 0.1183

$Q_g$ = 1.85 cfs

$Q_o$ = 36.54 cfs; $V_o$ = 2.91 fps; $V_o^2/2g$ = 0.1315

$H_u - H_o = V_o^2/2g - Q_u/Q_o\ (V_u^2/2g)$

$H_u - H_o = 0.1315 - (0.9494 \times 0.1183)$

$H_u - H_o - 0.1315 - 0.1123 = 0.02'$

## E - DESIGN COMPUTATIONS

n Frequency - 2 Year
nings "n" = 0.013
n -
file -

Sheet 14 of 14
Computed By - DCM
Checked By -

| V²/2g | Time in Minutes t | Time in Minutes Σt | Constr. Slope % | Req'd Hydr. Slope % | Struct. Head Loss | Hydraulic Grade Elevation Upper | Hydraulic Grade Elevation Lower | Structure Flowline Elevation Upper | Structure Flowline Elevation Lower | Upper Street Elev. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 979 | 0.19 | 22.09 | .30 | .36 | 0.30 | 1342.08 | 1341.64 | 1344.50 | 1344.36 | 1348.95 | H.G. Elev. 6.8' below gutter F.L. |
| 166 | 1.31 | 23.40 | .20 | .15 | -0.03 | 1341.67 | 1341.35 | 1343.86 | 1341.00 | 1348.95 | Ditto = 7.3' below |
| 351 | 0.23 | 21.90 | .30 | .25 | 0.21 | 1342.92 | 1342.61 | 1344.50 | 1344.36 | 1348.95 | Ditto = 6' below |
| 732 | 1.07 | 22.97 | .20 | .22 | 0.16 | 1342.45 | 1341.98 | 1343.86 | 1343.32 | 1348.95 | Ditto = 6.5' below |
| 002 | 0.26 | 23.23 | .15 | .09 | 0.06 | 1341.92 | 1341.88 | 1342.82 | 1342.74 | 1348.95 | Ditto = 7.0' below |
| 924 | 1.06 | 24.29 | .15 | .18 | 0.12 | 1341.76 | 1341.35 | 1342.64 | 1341.00 | 1348.95 | Ditto = 7.2' below |
| 521 | 0.85 | 25.14 | .10 | .09 | 0.08 | 1341.21 | 1341.07 | 1339.90 | 1338.30 | 1347.00 | Ditto = 5.8' below |
| 183 | 0.24 | 25.38 | .08 | .06 | -0.01 | 1341.08 | 1341.06 | 1337.80 | 1337.76 | 1345.55 | Ditto = 4.4' below |
| 315 | 1.03 | 26.41 | .08 | .06 | 0.02 | 1341.04 | 1340.93 | 1337.76 | 1337.58 | 1345.55 | Ditto = 4.5' below |

SUNRIDGE - TEAL BROOK ADD'NS - System 90

HYDROLOGY DATA COMPILATION

DRAINAGE CONCEPT

A. Initial Data

Use Rational Method - Q = CIA

1. Determine "C" Factors for Sub-Basins

| Node | Soil Type | Land Use | $C_2$ | $C_{100}$ |
|---|---|---|---|---|
| 97 | B | Res., 2/5 Acre | 0.37 | 0.55 |
| 96 | B | " | 0.37 | 0.55 |
| 95 | B | " | 0.37 | 0.55 |
| 94 | B | " | 0.37 | 0.55 |
| 93 | B | " | 0.37 | 0.55 |
| 92 | B | " | 0.37 | 0.55 |
| 91 | B | " | 0.37 | 0.55 |
| 90 | (Outlet to Detention Pond #1) | | | |

2. Determine $T_c$ & I for Each Sub-Basin

| Node | $T_c$ | $I_2$ | $I_{100}$ |
|---|---|---|---|
| 97 | $t_o$=8.33<br>$t_g$=4.42<br>$T_c$=12.75 Use 15 | 3.83 | 7.37 |
| 96 | 15 | 3.83 | 7.37 |
| 95 | 15 | 3.83 | 7.37 |
| 94 | $t_o$=12.5<br>$t_g$= 2.2<br>$T_c$=14.7 Use 15 | 3.83 | 7.37 |
| 93 | $t_o$=13.33<br>$t_g$= 2.33<br>$T_c$=15.66 | 3.76 | 7.24 |
| 92 | 15 | 3.83 | 7.37 |
| 91 | 15 | 3.83 | 7.37 |
| 90 | (Outlet to Detention Pond #1) | | |

3. - Determine Area, "A", of Sub-Basins Contributing to each Node

| Node | Area (Acres) | | |
|---|---|---|---|
| 97 | (N) 1.92 + 1.73 (E) | = | 3.65 |
| 96 | (N) 0.70 + 1.13 (E) | = | 1.83 |
| 95 | (E) 0.65 + 0.79 (W) | = | 1.44 |
| 94 | (E) 1.84 + 1.95 (W) | = | 3.79 |
| 93 | (N & W) 2.80 | = | 3.33 |
| 92 | (E) 0.58 + 0.73 (N) | = | 1.31 |
| 91 | (W & N) 0.99 | = | 0.99 |
| 90 | (Outlet to Detention Pond #1) | | |

4. - Determine Surface Contribution ($Q_2$) to Each Node

| Node | $C_2$ | $I_2$ | A | $Q_2$ |
|---|---|---|---|---|
| 97 | 0.37 | 3.83 | 3.65 | 5.17 |
| 96 | 0.37 | 3.83 | 1.83 | 2.59 |
| 95 | 0.37 | 3.83 | 1.44 | 2.04 |
| 94 | 0.37 | 3.83 | 3.79 | 5.37 |
| 93 | 0.37 | 3.76 | 3.33 | 4.63 |
| 92 | 0.37 | 3.83 | 1.31 | 1.86 |
| 91 | 0.37 | 3.83 | 0.99 | 1.40 |
| 90 | (Outlet) | | | |

5. Determine Surface Contribution ($Q_{100}$) to Each Node

| Node | $C_{100}$ | $I_{100}$ | A | $Q_{100}$ |
|---|---|---|---|---|
| 97 | 0.55 | 7.37 | 3.65 | 14.80 |
| 96 | 0.55 | 7.37 | 1.83 | 7.42 |
| 95 | 0.55 | 7.37 | 1.44 | 5.84 |
| 94 | 0.55 | 7.37 | 3.79 | 15.36 |
| 93 | 0.55 | 7.24 | 3.33 | 13.26 |
| 92 | 0.55 | 7.37 | 1.31 | 5.31 |
| 91 | 0.55 | 7.37 | 0.99 | 4.01 |
| 90 | (Outlet to Detention Pond #1) | | | |

6. Flood Routing/Inlet Sizing - 2 Year Design Storm

| Node | Inlet Condition | Inlet Length | $Q_2$ Approach | $Q_2$ Intercept | $Q_2$ By-Pass | By-Pass To Node |
|---|---|---|---|---|---|---|
| 97 | Sump | 5 | 5.17 | 5.17 | 0 | - |
| 96 | Sump | 5 | 2.59 | 2.59 | 0 | - |
| 95 | Sump | 5 | 1.44 | 1.44 | 0 | - |
| 94 | Sump | 5 | 5.37 | 5.37 | 0 | - |
| 93 | Sump | 5 | 4.63 | 4.63 | 0 | - |
| 92 | Sump | 5 | 1.86 | 1.86 | 0 | - |
| 91 | Sump | 5 | 1.40 | 1.40 | 0 | - |
| 90 | (Outlet to Detention Pond #1) | | | | | |

7. Flood Routing/Inlet Sizing - 100 Yr. Design Storm

| Node | Inlet Condition | Inlet Length | $Q_{100}$ Approach | $Q_{100}$ Intercept | $Q_{100}$ By-Pass | By-Pass To Node |
|---|---|---|---|---|---|---|
| 97 | Sump | 5 | 14.80 | 9.5 | 5.30 | Pond #2 |
| 96 | Sump | 5 | 7.42 | 7.42 | - | - |
| 95 | Sump | 5 | 5.84 | 5.84 | - | - |
| 94 | Sump | 5 | 15.36 | 9.5 | 5.86 | 95 & Pond #1 |
| 93 | Sump | 5 | 13.26 | 9.5 | 3.76 | 92 |
| 92 | Grade | 5 | 3.76<br>5.31<br>9.07 | 9.07 | 0 | - |
| 91 | Sump | 5 | 4.01 | 4.01 | 0 | - |
| 90 | (Outlet to Detention Pond #1) | | | | | |

8. Street Flow Depths - 2 Yr. Design Storm

| Node | $Q_2$ Approach | Flow Distribution | Street Slope | Flow Depth | Allowable Depth | Comment |
|---|---|---|---|---|---|---|
| 97 | 5.17 | 53% (NW) = 2.74 | 0.39 | 0.30 | 0.30 | OK |
| | | 47% (E) = 2.43 | 0.87 | 0.25 | 0.30 | OK |
| 96 | 2.59 | 38% (N) = 0.98 | 0.39 | 0.20 | 0.30 | OK |
| | | 62% (E) = 1.16 | 0.87 | 0.18 | 0.30 | OK |
| 95 | 1.44 | 45% (E) = 0.65 | 0.90 | 0.15 | 0.30 | OK |
| | | 55% (W) = 0.79 | 0.36 | 0.19 | 0.30 | OK |
| 94 | 5.37 | 49% (E) = 2.63 | 0.90 | 0.25 | 0.30 | OK |
| | | 51% (W) = 2.74 | 0.36 | 0.30 | 0.30 | OK |
| 93 | 4.63 | 100% (N) = 4.63 | 0.60 | 0.32 | 0.30 | .02 over OK |
| 92 | 1.86 | 44% (E) = 0.82 | 0.77 | 0.16 | 0.30 | OK |
| | | 56% (N) = 1.04 | 0.60 | 0.19 | 0.30 | OK |
| 91 | 1.40 | 100% = 1.40 | 0.50 | 0.22 | 0.30 | OK |
| 90 | (Outlet to Detention Pond #1) | | | | | |

SUNRIDGE - TEAL BROOK HYDROLOGY - SYSTEM 90 - 2 YR. FREQUENCY

| SURFACE TRIBUTARY AREA | | | | | | HYDROLOGY SUMMATION | | | | CONDUIT DATA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Node To Node | "C"2 | Area (Ac.) | $T_c$ (Min.) | $I_2$ | $Q_2$ (cfs) | $T_c$ (Min.) | $I_2$ | $Q_2$ (cfs) | $\Sigma Q_2$ | Size | Vel. (fps) | Length | T.T. | T.T. + T.C. |
| 97 | 0.37 | 3.65 | 15 | 3.83 | 5.17 | 15 | 3.83 | 5.17 | 5.17 | No pipe - Direct Discharge to Pond #2 | | | | |
| 96 | 0.37 | 1.83 | 15 | 3.83 | 2.59 | 15 | 3.83 | 2.59 | 2.59 | No pipe - Direct Discharge to R.C.B.C. | | | | |
| 95 | 0.37 | 1.44 | 15 | 3.83 | 2.04 | 15 | 3.83 | 2.04 | 2.04 | No pipe - Direct Discharge to Pond #1 | | | | |
| 94 | 0.37 | 3.79 | 15 | 3.83 | 5.37 | 15 | 3.83 | 5.37 | 5.37 | No pipe - Direct Discharge to R.C.B.C. | | | | |
| 93-92 | 0.37 | 3.33 | 15.66 | 3.76 | 4.63 | 15.66 | 3.76 | 4.63 | 4.63 | 18" | 2.62 | 60 | 0.38 | 16.04 |
| 92-91 | 0.37 | 1.31 | 15 | 3.83 | 1.86 | 16.04 | 3.72 | 1.80 | 6.43 | 24" | 2.05 | 225 | 1.83 | 17.87 |
| 91-90 | 0.37 | 0.99 | 15 | 3.83 | 1.40 | 17.87 | 3.52 | 1.29 | 7.72 | 24" | 2.46 | 180 | 1.22 | 19.09 |

90 (Outlet to Detention Pond #1)

SUNRIDGE - TEAL BROOK HYDROLOGY - SYSTEM 90 - 100 YR. FREQUENCY

| SURFACE TRIBUTARY AREA | | | | | | HYDROLOGY SUMMATION | | | | CONDUIT DATA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Node To Node | "C"100 | Area (Ac.) | $T_c$ (Min.) | $I_{100}$ | $Q_{100}$ (cfs) | $T_c$ (Min.) | $I_{100}$ | $Q_{100}$ (cfs) | $\Sigma Q_{100}$ | Size | Vel. (fps) | Length | T.T. | T.T. +T.C. |
| 97 | 0.55 | 3.65 | 15 | 7.37 | 14.80 | 15 | 7.37 | 14.80 | 14.80 | -- Direct Discharge to Pond #2 | | | | |
| 96 | 0.55 | 1.83 | 15 | 7.37 | 7.42 | 15 | 7.37 | 7.42 | 7.42 | -- Direct Discharge to R.C.B.C. | | | | |
| 95 | 0.55 | 1.44 | 15 | 7.37 | 5.84 | 15 | 7.37 | 5.84 | 5.84 | -- Direct Discharge to Pond #1 | | | | |
| 94 | 0.55 | 3.79 | 15 | 7.37 | 15.36 | 15 | 7.37 | 15.36 | 15.36 | -- Direct Discharge to R.C.B.C. | | | | |
| 93-92 | 0.55 | 3.33 | 15.66 | 7.24 | 13.26 | 15.66 | 7.24 | 13.26 | 13.26 | 18" | 7.50 | 60 | 0.13 | 15.79 |
| 92-91 | 0.55 | 1.31 | 15 | 7.37 | 5.31 | 15.79 | 7.22 | 5.20 | 18.46 | 24" | 5.88 | 225 | 0.64 | 16.43 |
| 91-90 | 0.55 | 0.99 | 15 | 7.37 | 4.01 | 16.43 | 7.11 | 3.87 | 22.33 | 24" | 7.11 | 180 | 0.42 | 16.85 |
| 90 | (Outlet to Detention Pond #1) | | | | | | | | | | | | | |

STRUCTURE HEAD LOSS COMPUTATIONS - SYSTEM 90

Structure 93 - Curb Inlet - $Q_o$ only

$Q_o$ = 4.63 cfs; $D_o$ = 18"; $V_o$ = 2.62 fps; $V_o^2/2g = 0.1066$

To geneate initial velocity, $H_v = V_o^2/2g = 0.11'$

+ entrance loss into 18" pipe, $H_e = 0.5 \times V_o^2/2g = 0.05'$

Total Structure Headloss = 0.11' + 0.05' = 0.16'

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Structure 92 - Curb Inlet + Upstream Flow

$Q_u$ = 4.63 cfs; $V_u$ = 2.62 fps; $V_u^2/2g = 0.1066$

$Q_g$ = 1.80 cfs

$Q_o$ = 6.43 cfs; $V_o$ = 2.05 fps; $V_o^2/2g = 0.0653$

$H_u - H_o = V_o^2/2g - Q_u/Q_o\ (V_u^2/2g)$

$H_u - H_o = 0.0653 - (0.7201 \times 0.1066)$

$H_u - H_o = 0.0653 - 0.0768 = -0.01'$

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Structure 91 - Curb Inlet + Lateral Flow

$Q_e$ = 6.43 cfs; $V_e$ = 2.05 fps; $V_e^2/2g = 0.0653$

$Q_g$ = 1.29 cfs

$Q_o$ = 7.72 cfs; $V_o$ = 2.46 fps; $V_o^2/2g = 0.0940$

$H_e - H_o = V_o^2/2g - Q_e/Q_o\ (0.7\ V_e^2/2g)$

$H_e - H_o = 0.0940 - 6.43/7.72\ (0.7 \times 0.0653)$

$H_e - H_o = 0.0940 - 0.0381 = 0.06'$

# STORM DRAINAGE - DESIGN COMPUTATIONS

Project - Sunridge & TEal Brood Additions - Storm Water Sewers - System 90

Design Storm Frequency - 2 Year
Mannings "n" = 0.013
Plan -
Profile -

Sheet 8 of 8
Computed By - DCM
Checked By -

| | Line | | Length | Struct. | Tributary Area (Ac.) @ "C" = | | Unit Runoff CFS/Ac. (C x I) | Total Runoff (CFS) | Pipe Size | Pipe Friction Head | V. | $\frac{V^2}{2g}$ | Time in Minutes | | Constr. Slope % | Req'd Hydr. Slope % | Struct. Head Loss | Hydraulic Grade Elevation | | Structure Flowline Elevation | | Upper Street Elev. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upper | Lower | | | Add | Total | | | | | | | t | Σt | | | | Upper | Lower | Upper | Lower | | |
| 1 | 93 | 92 | 60 | Curb Inlet | 3.33 | 3.33 | 1.39 | 4.63 | 18" | .12 | 2.62 | .1066 | 0.38 | 16.04 | .35 | .19 | 0.16 | 1341.65 | 1341.37 | 1339.10 | 1338.89 | 1343.55 | H.G. Elev. = 1.9' below Gutter F.L. |
| 2 | 92 | 91 | 225 | " | 1.31 | 4.64 | 1.38 | 6.43 | 24" | .18 | 2.05 | .0653 | 1.83 | 17.87 | .25 | .08 | -0.01 | 1341.38 | 1341.20 | 1338.39 | 1337.83 | 1343.20 | Ditto = 1.8' below |
| 3 | 91 | 90 | 180 | " | 0.99 | 5.63 | 1.37 | 7.72 | 24" | .21 | 2.46 | .0940 | 1.22 | 19.09 | .25 | .12 | 0.06 | 1341.14 | 1340.93 | 1337.73 | 1337.28 | 1343.45 | Ditto - 2.3' below |
| 4 | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | |

# REPORT ON FLOOD ROUTING AND DETENTION OF STORM WATER

## TEAL BROOK ESTATES AND SUNRIDGE ADDITION

Teal Brook Estates and Sunridge Addition occupy the east 65 acres of the north one-half of the northeast quarter of Section 12, T27S, R2W at the southwestern corner of 21st Street North and 119th Street West. The two subdivisions propose to lot out the last parcel of land east of the Regulatory Floodway of Cowskin Creek in a section which has seen remarkable growth in the past several years. The 65 acre parcel, which has been farmed as a separate unit from the land to the south, generally slopes from 119th Street toward Cowskin Creek and is well drained by a series of field swales and waterways and a well defined draw running thru Teal Brook Estates which serves a 55 acre drainage area in Cedar Downs Estates north of 21st Street as well as the land being developed. This draw, which is the location of the two small lakes being planned for Teal Brook Estates, exits from the 65 acres being developed at its southwest corner and runs both north and south along an old oxbow of Cowskin Creek.

The Drainage Concept for the combined Teal Brook Estates and Sunridge Addition area is to collect stormwater from the streets in Sunridge Addition and direct it via a storm water sewer across part of Teal Brook Estates to Lake # 1 which is to be located astride the existing draw about midway between 21st Street and the south property line. Runoff from Cedar Downs Estates north of 21st Street, right of way for 21st, a commercial corner at 21st and 119th and the lots in Teal Brook Estates along Cornelison Street will also be collected in Lake # 1 via a drainage channel from 21st to the Lake. Runoff from the western portion of Teal Brook Estates will be collected from the two upper Teal Brook Courts and Teal Brook Drive in a storm water sewer which also discharges into Lake # 1. The rear portion of lots bordering Lake # 1 will drain directly into the Lake.

A combination of small diameter pipe and broadcrested weir forms the proposed spillway of the Lake to limit the calculated outflow discharge rate from both the 5-year frequency and 100-year frequency storms to less than they produce with existing conditions.

The balance of Teal Brook Estates will drain into Lake # 2 which is located at the extreme southwest corner of the 65 acre tract and the calculated outflow from Lake # 2 will also be controlled to limit the discharge rate for both the 5-year frequency and 100-year frequency storms to less than that for existing conditions. Here also the spillway is a combination of small diameter pipe and a broadcrested weir. A short outfall channel will connect the Lake Number 2 spillway to the old Cowskin oxbow.

Since the drainage areas and drainageways contributing to the lake system have considerably different lengths and therefore different times of concentration, the proper way to calculate the combined effect of runoff from them under both existing and developed conditions is to construct hydrographs for each of the separate areas and to combine those hydrographs to determine the peak discharge rate at a point in question, in this case at each of the two lakes. Hydrographs are also needed to determine the peak discharge rate reduction provided by the lake-spillway combinations and to calculate the peak outflow discharge rate for the off-site waterway design.

Peak discharge rates for each sub-area in the Sunridge and Teal Brook Estates storm water sewer systems were calculated by the Rational Method, procedure and tables contained in the City of Wichita publication titled "Interim Drainage and Storm Sewer Policy". Peak discharge rates for all other sub-areas were calculated by the Rational Method using tables from the same publication. Hydrographs for the outlet points of the two storm water sewers and for each other sub-area were calculated using the SCS Unit Hydrograph Method included in the Corps of Engineers Computer Program HEC-1, Flood Hydrograph Package. Rainfall for each of the storm frequencies analyzed was distributed by using the SCS distribution for the 6-hour storm and the parameters of the SCS unit hydrograph were adjusted so that the peak discharge rate was the same as calculated by the Rational Method. Hydrographs were combined at points of interest and routed thru the storage provided by the lake-spillway combinations.

For each condition analyzed, a calculation sheet for each of the parameters used in the various hydrographs is provided with this report and copies of the HEC-1 printouts are also supplied. The net result of the analysis of the effect of development of Teal Brook Estates and Sunridge Addition is to reduce the peak discharge rate leaving the 65 acre parcel from 126 cfs for the 5-year frequency storm with existing conditions to 50 cfs; and to reduce the peak discharge rate for the 100-year frequency storm with existing conditions from 223 cfs to 152 cfs.

The following exhibits are provided to support the conclusions described above:

Exhibit A. Excerpt from enlargement of USGS 15-minute quadrangle map showing the general outline of the areas draining to and across the proposed development.

Exhibit B. Print of topographic map showing drainage area boundaries and stream lines for existing conditions in Sunridge Addition and Teal Brook Estates.

Exhibit C. Print of Drainage Study map showing drainage area boundaries and storm sewer systems for the two sub-divisions as designed by Moehring.

Exhibit D. Copy of calculation sheet for variables for SCS Hydrographs for the 5-year frequency storm with existing conditions and copy of printout from the HEC-1 program for those hydrographs and the sum at the existing outlet.

Exhibit E. Copy of calculation sheet for variables for SCS Hydrographs for the 100-year frequency storm with existing conditions and copy of printout from HEC-1 program for those hydrographs and the sum at the existing outlet.

Exhibit F. Copy of calculation sheet for variables for SCS Hydrographs for the 2-year frequency storm for developed conditions for the drainage areas contributing to Lake # 1 and copy of printout from HEC-1 program for those hydrographs and for routing of the peak discharge rate thru the Lake # 1 storage-spillway combination to determine the starting water surface elevation to calculate the hydraulic grade line elevations for the Sunridge Addition and Teal Brook Estates storm water sewers.

Exhibit G. Copy of calculation sheet for variables for SCS Hydrographs for the 5-year frequency storm for developed conditions for the drainage areas contributing to both Lake # 1 and Lake # 2 and copy of printout from HEC-1 program for those hydrographs and for routing of the peak discharge rate thru the storage-spillway combinations for both lakes.

Exhibit H. Copy of calculation sheet for variables for SCS Hydrographs for the 100-year frequency storm for developed conditions for the drainage areas contributing to both Lake # 1 and Lake # 2 and copy of printout from HEC-1 program for those hydrographs and for routing of the peak discharge rate thru the storage-spillway combinations for both lakes.

Exhibit I. Miscellaneous calculations for time of concentration, drainage area, lake area-depth-volume tables, rational c-factors, etc.

Exhibit J. HEC-1 Computer Program Input File Descriptions.

END OF REPORT

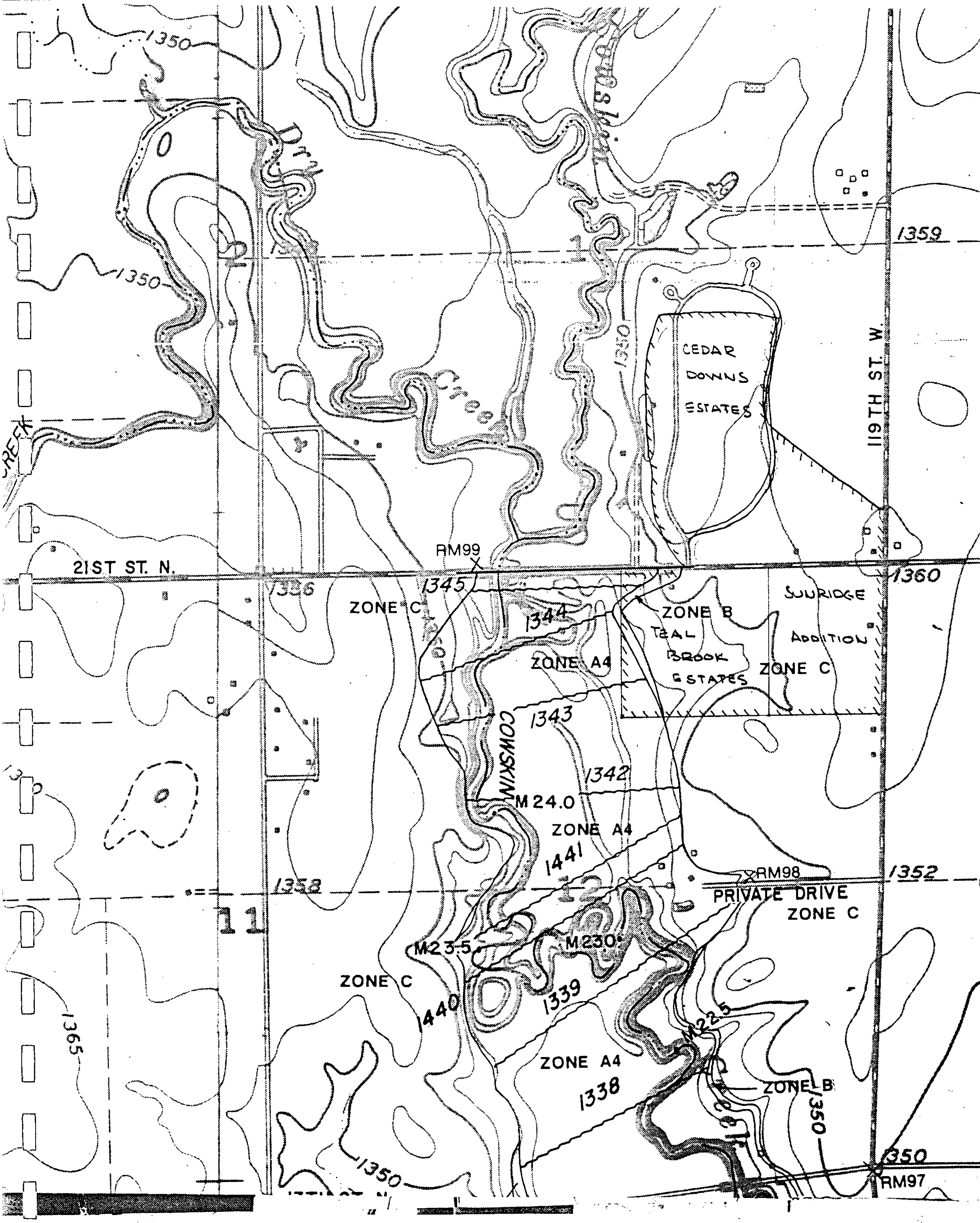
1350
1350
21ST ST. N.
RM99
1345
ZONE C
1344
ZONE A4
CEDAR DOWNS ESTATES
119TH ST. W.
1359
1360
ZONE B
TEAL BROOK ESTATES
SUNRIDGE ADDITION
ZONE C
1343
COWSKIN
1342
M 24.0
ZONE A4
1441
1358
11
RM98
1352
PRIVATE DRIVE
ZONE C
M23.5
M230
ZONE C
1440
1339
M22.5
ZONE A4
1338
ZONE B
1350
1365
1350
1350
RM97

**Exhibit A**