STORM WATER

TECHNICAL MANUAL

Appendix “D”

May 2008

A summary of storm water design requirements and technical data for the use in preparing storm water drainage systems in American Fork.

Information was compiled from the following City Documents

American Fork City Storm Drain Element of the General Plan - May 2004
prepared by RB&G Engineering, Inc

American Fork City Storm Water Management Program – April 2004
prepared by J-U-B Engineers, Inc

Unless provided otherwise, the criteria and methods presented in the following references should be used in planning and design of the drainage system.

"Urban Storm Drain Criteria Manual", June 2001, or latest revision
Urban Drainage and Flood Control District
http://www.udfcd.org

This Storm Water Technical Manual contains requirements for land development and construction activities, as well as design criteria and guidelines for those performing such activities in American Fork City. The City Engineer has authority to modify these requirements of the Storm Water Technical Manual as needed to meet changing or unusual needs or conditions.

Section A Storm Water Runoff Analysis Methods & Information

1.0 Loss Rates and Infiltration Methods

Three acceptable methods to determine the amount of storm water runoff are presented here for the use in designing storm water collection systems in American Fork.

1.1. SCS Curve Number

The SCS Curve Number method is the most versatile. The method is more appropriate for storm drain designs on systems with large areas of soil and vegetative cover and can be adjusted for the presence of impervious area within the watershed. The SCS Curve Number method uses a curve number (CN) which ranges from 0 to 100 to represent the infiltration capacity of the soil/vegetative cover complex of an area. Computed runoff is 100 percent for a CN of 100 and zero for a CN of 0, but is non-linear between these values. The depth of runoff is computed using the equation:

$$\mathbf{Q = (P-0.2S)^2 / (P+0.8S)}$$

where Q = computed runoff depth in inches
P = rainfall depth in inches
S = 1000/CN – 10

This equation includes an initial abstraction component to account for the rainfall required for wetting prior to initiation of runoff. Curve numbers are selected based on soil type and vegetative cover type. Soil types are represented by four hydrologic soils groups: A, B, C, and D designated in order of greatest infiltration capacity to the least. Soil groups are determined from the soils maps prepared by the National Resource Conservation Service, formerly the U.S. Soil Conservation Service (SCS), soil survey for the Utah County area (NRCS, 1972) and Table 3.2 of the soil survey publication. Figure 1 shows the soil association map from this publication for the American Fork area. The hydrologic soils group for the soil associations of Figure 1 are shown in Table 1.1.

Figure 1

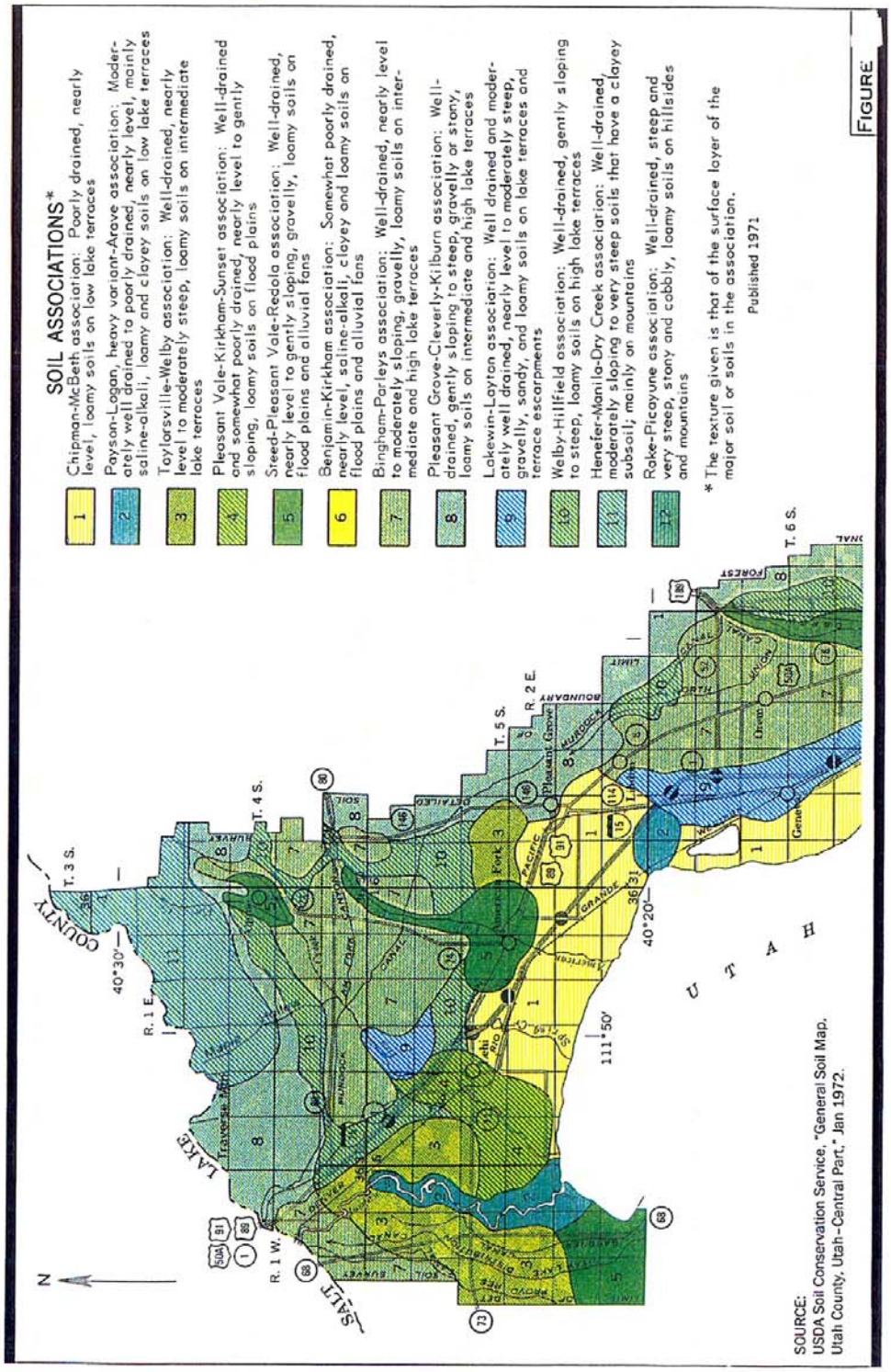

SOIL ASSOCIATIONS*
1 Chipman-McBeth association: Poorly drained, nearly level, loamy soils on low lake terraces
2 Payson-Logan, heavy variant-Arave association: Moderately well drained to poorly drained, nearly level, mainly saline-alkali, loamy and clayey soils on low lake terraces
3 Taylorsville-Welby association: Well-drained, nearly level to moderately steep, loamy soils on intermediate lake terraces
4 Pleasant Vale-Kirkham-Sunset association: Well-drained and somewhat poorly drained, nearly level to gently sloping, loamy soils on flood plains
5 Steed-Pleasant Vale-Redola association: Well-drained, nearly level to gently sloping, gravelly, loamy soils on flood plains and alluvial fans
6 Benjamin-Kirkham association: Somewhat poorly drained, nearly level, saline-alkali, clayey and loamy soils on flood plains and alluvial fans
7 Bingham-Parleys association: Well-drained, nearly level to moderately sloping, gravelly, loamy soils on intermediate and high lake terraces
8 Pleasant Grove-Cleverly-Kilburn association: Well-drained, gently sloping to steep, gravelly or stony, loamy soils on intermediate and high lake terraces
9 Lakewin-Layton association: Well drained and moderately well drained, nearly level to moderately steep, gravelly, sandy, and loamy soils on lake terraces and terrace escarpments
10 Welby-Hillfield association: Well-drained, gently sloping to steep, loamy soils on high lake terraces
11 Henefer-Manila-Dry Creek association: Well-drained, moderately sloping to very steep soils that have a clayey subsoil; mainly on mountains
12 Rake-Picayune association: Well-drained, steep and very steep, stony and cobbly, loamy soils on hillsides and mountains
* The texture given is that of the surface layer of the major soil or soils in the association.
Published 1971
FIGURE
SOURCE:
USDA Soil Conservation Service, "General Soil Map, Utah County, Utah-Central Part," Jan 1972.
N
UTAH
SALT LAKE COUNTY
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
R. 1 E.
R. 1 W.
R. 2 E.
40°30'
40°20'
111°50'
Pleasant Grove
American Fork
Lehi
Alpine
Highland
Cedar Hills
Provo
Orem
Geneva
Lindon
Vineyard
Saratoga Springs
Eagle Mountain
Tickville
Fairfield
Cedar Fort
Camp Williams
Traverse Mtn.
Dry Creek
Mt. Pleasant
Pacific
Grand
Union
Mt. Pleasant
Forest
Limit
Boundary
Detailed
Soil
Survey
Mt. Pleasant
Mt. Pleasant
Mt. Pleasant

Table 1.1
American Fork City
Hydrologic Soils Groups

Association No.	Association Name	Hydrologic Soils Group
1	Chipman – Mcbeth	C - in drained areas
		D - in undrained areas
3	Taylorsville – Welby	D - for Taylorsville
		B – for Welby
5	Steed - Pleasant Vale - Redola	A- for Steed
		B - for Pleasant Vale
		B – for Redola
7	Bingham – Parleys	B
10	Welby – Hillfield	B

Figure 1 can be used directly to determine the hydrologic soils group for areas in soil association Nos. 7 and 10. The more detailed maps of the soil survey are needed to determine the appropriate hydrologic soils groups for areas of soil association Nos. 1, 3 and 5.

The SCS Curve Number method was developed for agricultural areas, but can be used for natural and urban watersheds with the selection of a proper curve number (CN). Curve numbers for natural and urban areas are found in publication TR 55 of the NRCS (NRCS, 1975). Selected values which are recommended for the American Fork City area are shown for convenience in Table 1.2. This table, along with the appropriate hydrologic soils group obtained either from Figure 1 or the more detailed maps provided in the SCS soil survey, should be used to select the proper curve number. The selected curve number must be adjusted for the presence of impervious area as per the chart in Figure 2 taken from TR 55. Often, for larger watersheds or watersheds with multiple vegetative types, a composite curve number will need to be determined. The composite curve number is computed by selecting the appropriate curve number for each vegetative cover/soil type of the watershed and computing the composite curve number as a weighted average based on the area of each vegetative cover/soil type. An example of this computation is shown in Table 1.3.

Table 1.2

Representative Values for SCS Runoff Curve Numbers
Agricultural, Suburban and Urban Land Use

(Antecedent Moisture Condition II, and $I_a = 0.2S$.)

Land Use Description		Hydrologic Soil Group			
		A	B	C	D
Cultivated land: without conservation treatment		72	81	88	91
with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
fair condition		54	70		
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential[3]:					
Average Lot Size	Average % Impervious [4]				
1/8 acres or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1 /2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers [5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

[1] For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

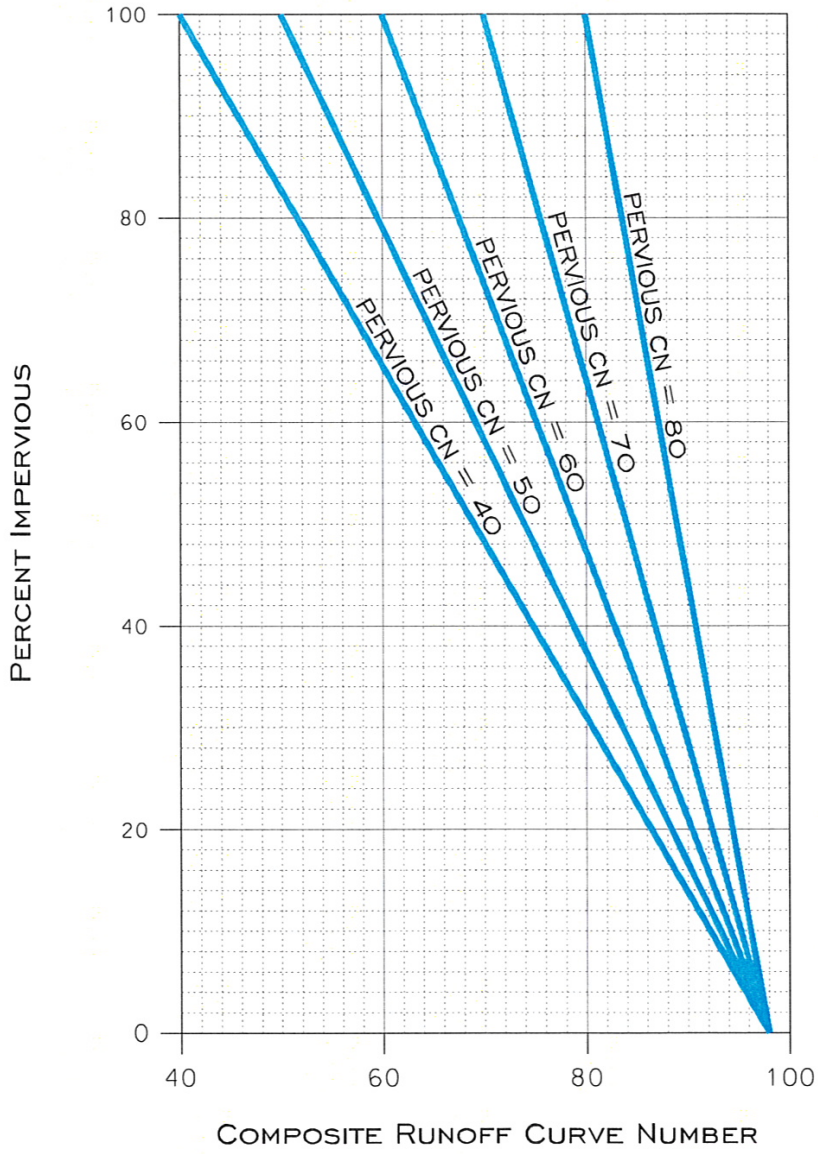
[2] Good cover is protected from grazing and litter and brush cover soil.

[3] Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[4] The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[5] In some warmer climates of the country a curve number of 95 may be used.

Figure 2



SOURCE: Natural Resources Conservation Service
Tr-55, Urban Hydrology for Small Watersheds
Jun. 1986 (Figure 2-3)

Figure

American Fork City

Storm Drain Element
General Plan
Percentage Of Impervious Areas vs.
Composite CN's For Given Pervious Area CN's

Table 1.3
Sample Composite Curve Number Calculation

Vegetative cover/soil type	Area (A) (acres)	Curve Number	Weight (A x CN)
Park	2.0	61	122
Commercial/business	2.0	94	188
Residential - 1/4 acre	3.0	83	249
Totals	7.0		559
Composite CN = Total Weight/Total Area = 559 / 7.0 = 79.9			

1.2. Initial Abstraction and Uniform Loss-rate

As an alternative for smaller drainages, or drainages with large amounts of impervious area, a simple and widely used method is to account for an initial abstraction of rainfall at the beginning of the storm, coupled with a uniform loss rate throughout the duration of the storm. The problem with this method is that infiltration studies of soils show conclusively that soils do not have constant infiltration rates, but have higher initial infiltration rates and progressively decreasing infiltration rates through time. Infiltration rates eventually stabilize at a relatively uniform rate only after the soil has become sufficiently saturated. However, the use of an initial abstraction and uniform loss rate to represent soil/vegetative wetting and soil infiltration will generally yield satisfactory results. The initial abstraction and uniform loss rates to be used for storm drainage analysis and design in American Fork are provided in Table 1.4.

Table 1.4

Impervious Percent and Infiltration Losses

Land Use/Cover	Impervious %	Initial Loss (inches)	Soils Group Uniform Loss (inches/hour)			
			A	B	C	D
Commercial/Highways/Parking	95	0.20	0.90	0.56	0.22	0.08
Apartments/Offices	75	0.20	1.04	0.64	0.24	0.10
Industry/Institutional	60	0.30	1.08	0.68	0.28	0.12
Residential: > 10 units/acre	50	0.30	0.90	0.60	0.30	0.15
Residential: > 6-10 units/acre	45	0.35	1.06	0.70	0.34	0.16
Residential: > 4-6 units/acre	40	0.40	1.14	0.75	0.36	0.17
Residential: > 3-4 units/acre	30	0.45	1.21	0.80	0.39	0.18
Residential: > 2-3 units/acre	20	0.50	1.28	0.84	0.40	0.19
Residential: > 1-2 units/acre	15	0.60	1.32	0.87	0.42	0.20
Residential: > 0.5-1 units/acre	10	0.70	1.36	0.90	0.44	0.21
Residential: > 0.2-0.5 units/acre	8	0.80	1.46	0.96	0.46	0.22
Residential: > 0.1-0.2 units/acre	5	0.90	1.48	0.98	0.48	0.23
Urban Lawns	0	0.30	1.00	0.64	0.28	0.15
Urban Landscaping/Gardens	0	1.00	1.50	1.00	0.50	0.25
Bare/Newly Graded	2	0.20	0.50	0.30	0.10	0.02
Irrigated Pasture	2	0.40	0.90	0.60	0.30	0.15
Wetlands	99	0.10	0.05	0.05	0.05	0.05
Grass/Weeds/Sagebrush	1	0.80	0.70	0.60	0.50	0.40
Scrub Oak/Brush/Grass	1	1.00	1.00	0.80	0.60	0.50
Conifers/Aspen/Brush	1	100	1.20	100	0.80	0.50

Source: Adapted from Salt Lake City Hydrology Manual

1.3. Rational Method

This method, though often criticized in the literature, nevertheless can provide satisfactory results for storm drainage design when appropriate watershed conditions are present. The method is for small drainage basins of less than 200 acres with constant or homogeneous soils and cover type throughout the basin. The Rational Method uses the equation:

$$Q=CIA$$

where Q = maximum rate of runoff in cubic feet per second (cfs)

C = a runoff coefficient which is the ratio between the maximum rate of runoff from the area and the average rate of rainfall intensity, in inches per hour, for the period of maximum rainfall of a given frequency of occurrence having a duration equal to the time of concentration. The factor depends upon the soils and cover type.

I = the average intensity of rainfall in inches per hour for a duration equal to the time of concentration.

A = drainage area in acres

Recommended C-values for various cover types are provided in Table 1.5.

Table 1.5

Recommended Rational "C" - Factors

Description	American Fork City Zoning	Normal Value "C"	Range of Values "C"
Open Land/Agricultural	RA-1, RA-2	0.10	0.10-0.30
Single Family Residential	R-1	0.35	0.25-0.50
Two Family Residential	R-2	0.40	0.50-0.70
Multiple Family Residential	R-3, R-4	0.40	0.50-0.70
Planned Residential	PR	0.40	0.50-0.70
Professional Office	PO	0.70	0.70-0.90
Commercial	CC, GC	0.70	0.70-0.90
Light Industrial	PI	0.60	0.50-0.80
General Industrial	I-1	0.60	0.50-0.80
Streets			
Asphaltic			0.70-0.95
Concrete			0.80-0.95
Drives and Walks			0.75-0.85
Roofs			0.75-0.95
Lawns, Sandy Soil			
Flat, 2%			0.05-0.10
Average, 2 to 7%			0.10-0.15
Steep, 7+%			0.15-0.20
Lawns, Heavy Soil			
Flat, 2%			0.15-0.20
Average, 2 to 7%			0.20-0.25
Steep, 7+%			0.25-0.35

The C-value in the low range should be used with soils of hydrologic soils group A while the high range C-value should be used with soils of hydrologic soils group D. An intermediate range C-value should be used for hydrologic soils groups B and C. Also, C-values should be adjusted upward for major storms such as the 100-year storm of the appropriate duration for the time of concentration. The values to be used for the frequency factor, C_f, in American Fork City are 1.0 for 2-year to 10- year storms, 1.1 for a 25-year storm, 1.2 for a 50-year storm, and 1.25 for a 100-year storm The equation for the 100-year storm then becomes:

$$Q = C_f C I A = 1.25 \; C I A$$

The greatest problem with the Rational Method is that it provides only the peak point on the runoff hydrograph when the full hydrograph is often needed for flood routing and detention storage design. Also, when basins become complex requiring combined peak discharge estimates from sub-basins, the Rational Method will tend to overestimate peak flow. Thus, the Rational Method should only be used in drainage designs in American Fork City for relatively homogenous drainage basins less than 200 acres in size needing no combining of peak flows from sub-basins, needing no storage detention design, and needing no routing of hydrographs through a downstream basin.

1.4 Conclusions

Based on the above discussion the loss rate/infiltration methods that are to be used in American Fork City are presented in Table 1.6

Table 1.6
Selection of Loss Rate Method

Drainage Area (acres)	Cover Type	Impervious Area	Hydrographs Needed	Method
<160	Urban	>40%	No	Rational
<160	Urban/Agric./Natural	0 to 40%	No	SCS CN
<160	Urban	>40%	Yes	Initial Loss/Uniform
<160	Urban/Agric./Natural	0 to 40%	Yes	SCS CN
<160	Urban	>40%	Yes/No	Initial Loss/Uniform
<160	Urban/Agric./Natural	0 to 40%	Yes/No	SCS CN

2.0 Time of Concentration

The time of concentration, Tc, is defined as the time it takes runoff to travel from the hydraulically most distant part of the watershed to the point of interest where the peak discharge or runoff hydrograph is desired. An estimate of the time of concentration is needed for determining the appropriate rainfall intensity for the Rational Method or for developing a runoff hydrograph using either the SCS Curve Number method or the Initial Abstraction and Uniform Loss Rate method. A number of methods are available to estimate the time of concentration for a drainage.

2.1 Summation of Travel Times

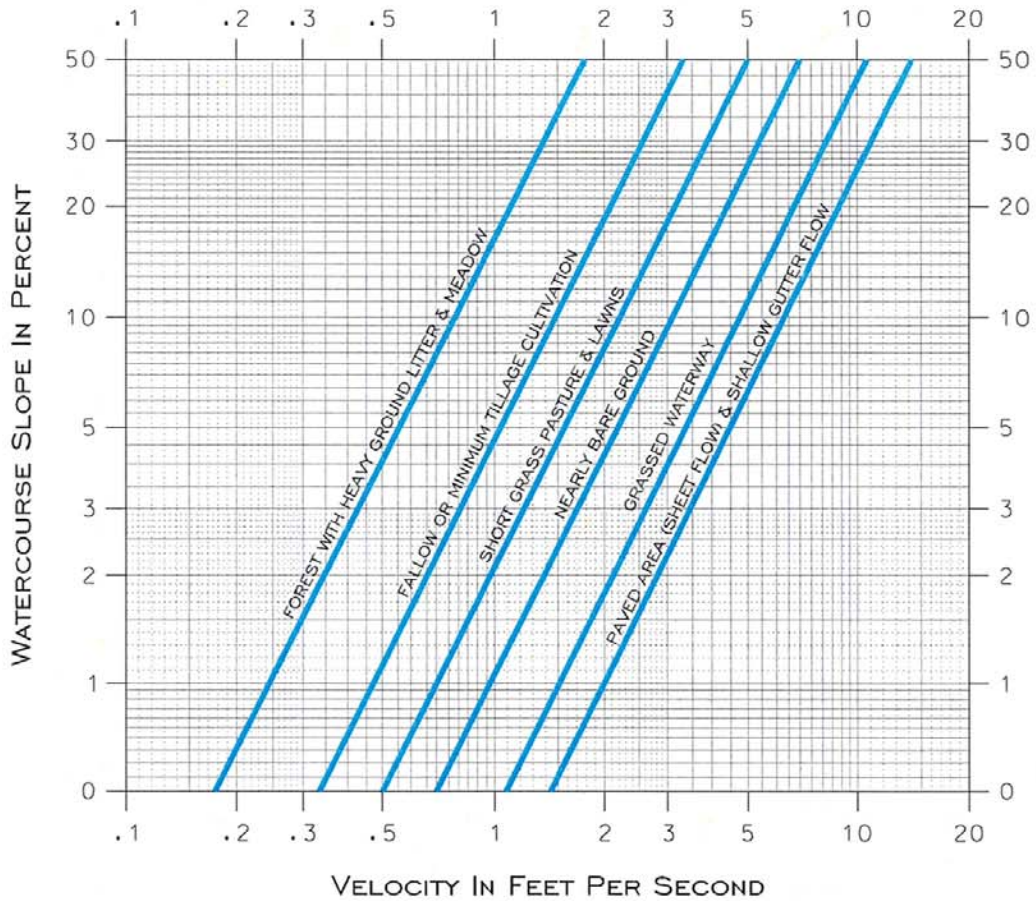
The preferred method is the Summation of Travel Times method. This method estimates the time of concentration as the summation of the travel times for each hydraulically different flow segment encountered as runoff water flows from the most distant part of the watershed to the point of interest. The time of concentration is thus computed as the total time required for runoff water to travel from the farthest point of the drainage through each hydraulically different segment of the drainage system within the drainage to the point of interest. This method is believed to be the most accurate of those available though it can be complex to compute for watersheds with numerous hydraulically different drainage conveyance segments. Usually the travel time computation begins with determining the time required for runoff to flow overland as shallow sheet or rill flow from the farthest point of the watershed to a drainage channel or storm inlet. The overland flow travel time can be estimated from overland flow curves provided in TR-55 which are shown here on Figure 2. Travel times from channel and pipe flow are, then, computed using Manning's equation to compute velocity. Manning's equation is:

$$v = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where V = velocity of flow in channel/pipe
R = hydraulic radius = flow area (A) divided by the wetted perimeter (WP)= A /WP
S = channel or pipe slope in ft/ft
n = Manning's roughness coefficient

Manning's coefficients for various types of channels and drainage pipeline materials are provided in Table 2.1. A caution should be noted in the analysis of travel times for natural hydraulic systems. Manning's equation may result in velocity estimates in the supercritical flow range. Supercritical flow is rare in natural systems due to irregularities in channel shape, roughness, and slope. In such natural systems, travel time velocities should be computed based on the critical flow equation.

Figure 3



SOURCE: FIGURE 15.2,
NRCS NATIONAL ENGINEERING HANDBOOK
SECTION 4, HYDROLOGY

FIGURE

AMERICAN FORK CITY

STORM DRAIN ELEMENT
GENERAL PLAN
AVERAGE VELOCITIES FOR ESTIMATING
TRAVEL TIME FOR OVERLAND FLOW

Table 2.1

Roughness Coefficients for Pipes/Channels/Floodplains

Type of Conveyance	Manning's Roughness Coefficient 'n'
Plastic pipe	.012
Steel/cast iron pipe	.013
Concrete pipe	.015
Corrugated metal pipe	.024
Corrugated multiplate arch culverts	.030
Concrete-lined channel	.016
Earth channel-straight/smooth	.022
Earth channel-dredged	.028
Grass trapezoidal ditch-straight/mowed	.030
Natural channel-straight/clean/uniform	.035
Natural channel-straight/pools and riffles	.040
Natural channel-winding/pools/uneven/aquatic weeds	.045
Natural channel-winding/stony/uneven/aquatic weeds	.050
Natural channel-winding/stony 5-20% vegetation-stiff weeds/cattails/brush	.060
Natural channel-winding/stony/pools 20-50% stiff vegetation (weeds/cattails/willows)	.070
Natural channel-winding/stony/pools 50-70% stiff vegetation	.080
Natural channel-winding/stony/pools 70-100% stiff vegetation	.100
Floodplain-pasture/short grass/smooth	.035
Floodplain-isolated trees/high grass/smooth	.040
Floodplain-isolated trees/high grass/uneven	.050
Floodplain-few trees/shrubs/tall weeds	.060
Floodplain-few trees/shrubs/tall weeds/uneven	.080
Floodplain scattered shrubs/trees/tall weeds	.100
Floodplain-scattered trees/shrubs/rocky	.120
Floodplain-numerous trees/shrubs/vines	.150
Floodplain-dense trees/shrubs/vines	.200

2.2 *Time of Concentration*

Other more empirical methods are available to estimate the time of concentration for agricultural or natural watersheds that have and will remain in or near their natural state. These empirical methods include among others the SCS time of concentration method and the Corps of Engineer watershed lag method. The methods are not for use in watersheds with significant urban impervious areas or with watersheds having channels that have been significantly modified from their natural state. The SCS TR 55 publication includes curves to fit the SCS time of concentration method to an urbanized watershed, but the curves are approximate at best and their use is discouraged. For urbanized watersheds the Summation of Travel Times method is preferred. The SCS time of concentration method relates the watershed lag, which is defined as the time in hours from the center of mass (the centroid) of excess rainfall to the peak rate of runoff, to the time of concentration. The equations are:

$$\mathrm{Lag} = \frac{L^{0.8}(S+1)^{0.7}}{1900\ Y^{0.5}} \quad \text{and} \quad \mathrm{Tc} = 0.6\ \mathrm{Lag}$$

where Tc = time of concentration (hours)
Lag = time in hours from the center of mass (the centroid) of excess rainfall to the peak rate of runoff
L = greatest flow length in feet
S = 1000/CN - 10
CN = curve number
Y = watershed average slope in percent

The average watershed slope is the average slope of the land and not the water course. The equation is for use on natural or agricultural watersheds with drainage areas less than 2000 acres and curve numbers between 50 and 95. The Corps of Engineers derived an alternative equation for estimating watershed lag as:

$$\mathrm{Lag} = F\left[\frac{(L \times Lc)}{\sqrt{S}}\right]^{0.38}$$

where Lag = time in hours from centroid of rainfall to the hydrograph peak
F = factor for watershed type
= 1.2 for mountain drainage

= 0.72 for foothill drainage
= 0.35 for valley drainage

L = length of main stream from the outlet to the divide in miles

Lc = distance from the outlet to a point on the stream nearest the centroid of the basin in miles

S = mean slope of the drainage in feet/mile

An F factor of 0.35 should be used for the American Fork City area. The time of concentration for the watershed can then be estimated from the lag computed using the Corps of Engineers equation and the SCS relationship between lag and time of concentration given above (Tc = 0.6 Lag).

3.0 Peak Discharge Estimates

Peak discharge is all that is needed for the design of simple storm drainage systems that do not require flood or storage routing or the combining of discharges from adjacent or upstream drainages. Peak discharge estimates for the 100-year design storm can be obtained using the Rational Method described above or using the SCS method described here.

3.1 SCS Triangular Hydrograph Method

Based on an assumption of a triangular hydrograph the following equation can also be used to estimate peak discharge.

$$Q_{pk} = \frac{(484\ A\ R)}{(0.5D_r + 0.6Tc)}$$

where Q_{pk} = peak discharge in cfs

A = drainage area in square miles

R = total runoff in inches = Q of the SCS Curve Number equation

D_r = the duration of rainfall in hours

Tc = time of concentration (see above)

This equation is also used in the SCS dimensionless hydrograph method described below to derive the unit hydrograph for the drainage basin in question.

4.0 Hydrographs

Storm runoff hydrographs are needed when designing detention basins, when analyzing drainage systems which require the combining of discharges from upstream or adjacent watersheds, or when routing flows through drainage channels. Unit hydrographs convert the inches of runoff computed using either the SCS Curve Number method or the Initial Abstraction and Uniform Loss Rate method into a design storm runoff hydrograph.

4.1 SCS Dimensionless Unit Hydrograph Method.

The SCS developed a dimensionless unit hydrograph from analysis of hydrographs from numerous basins. Its curvilinear form is a much better approximation of natural hydrographs than the triangular unit hydrograph approach. The SCS dimensionless unit hydrograph is believed sufficiently adaptable to urban watersheds through proper estimation of travel times and time of concentration.

4.2 The Farmer-Fletcher Distributions

The Farmer-Fletcher typical storm hydrographs and distribution curves with selected time steps have been prepared to assist in the routing flows through drainage channels. The curves were developed from taking points from Farmer-Fletcher Distribution of Precipitation in Mountainous Areas. These points were then developed into the following hydrographs.

1 hour - 1 minute time step
2 hour - 1 minute time step
3 hour - 3 minute time step
6 hour - 3 minute time step
24 hour - 6 minute time step

These 5 unit hydrographs with associated time steps can be used to derive all of the necessary design storms required to perform storm drain design in American Fork. See Appendix “A” for the figures and tables for each unit hydrograph.

Section B Storm Drain Conveyance System Criteria

5.0 Storm Drain Piping

Storm drain pipe sizes are to be able to convey the peak flows of the 25 year storm event as detailed below.

5.1 Design Storm – as per the following table of Rainfall Data

Table 3 – 25 year Storm Event

Duration	Intensity (in/hr)	Depth (in)
5 min	3.84	0.32
10 min	2.94	0.49
15 min	2.48	0.62
30 min	1.72	0.86
60 min	1.09	1.09
2 hr	0.62	1.24
3 hr	0.45	1.35
6 hr	0.26	1.56
24 hr	0.10	2.40

5.2 Storm Duration

5.2.1 Rational Method and SCS peak discharge method

The storm duration should be approximately equal to the computed time of concentration of the drainage.

5.2.2 Hydrograph

a. The greatest peak runoff flowrate produced from the 1-hour, 2-hour, 3-hour, or 6-hour durations of the 25-year storm event.

b. The Farmer-Fletcher type of storm Distribution should be used. See Appendix A.

6.0 Inlet Spacing

Inlet spacing is a function of street slope and storm water flow rate. Storm water must be delivered from the street to storm drains when flows reach amounts shown in the following graph, Figure 4. This means that for a given longitudinal street slope, flows on the street surface must be delivered into the underground piped system when they reach the amount indicated on the graph by the solid line.

6.1 Spread of water in the street

a. The storm water runoff must be delivered from the street into an underground piped system when the spread of water from the 25-year design storm event covers the outside 10 feet of asphalt.

6.2 Gutter Velocity

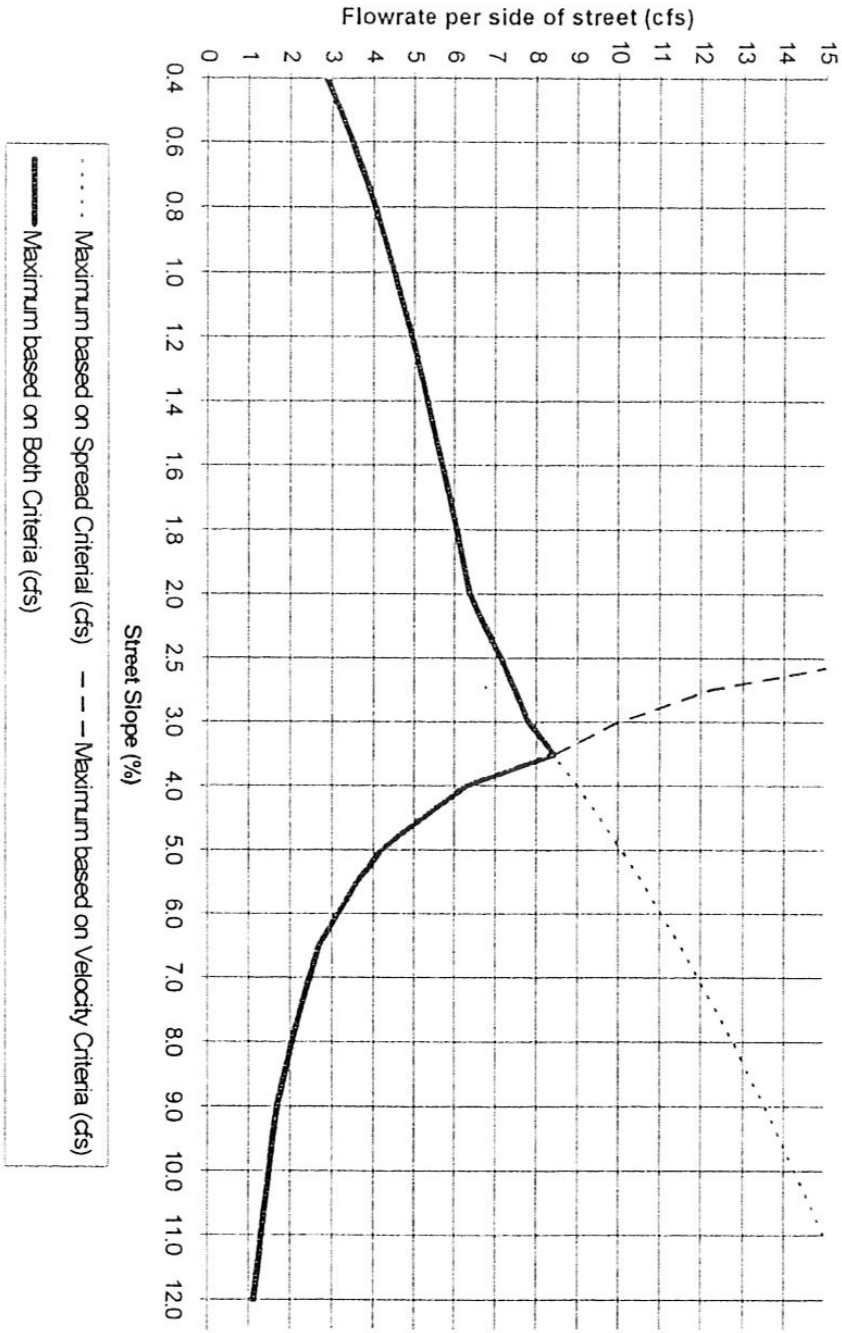
a. The storm water runoff must be delivered from the street into an underground piped system when the velocity of water in the deepest part of the gutter reaches 10 feet per second (fps) for the 25 year storm event.

6.3 Inlet Capacity

a. The designer is to assume 50% blockage of inlets when considering storm drain inlet capacity.

b. Additional inlet capacity is required near detention facilities to accommodate the capture of surface flows of the 100 year storm event. These additional inlets are to be designed to convey the 100 year storm event to the detention pond.

Figure 4



Note: The spread of water in the street is calculated using the Manning equation in the form developed by Izzard, with a roughness coefficient of 0.013 and the standard street cross section. The velocity criteria is based on the velocity at the deepest part of the gutter with the Manning Equation, with a roughness coefficient of 0.013, and using a depth at a point six inches from the face of the curb as the hydraulic radius.

Section C Storm Drain Detention Facility Design

7.0 Storm drain detention facilities, control the point of discharge and downstream flooding hazard abatement shall have the capacity to contain the 100-year storm event. The flooding hazard abatement shall be capable of passing the 100-year storm event without flooding buildings.

7.1 Design Storm – as per the following table of Rainfall Data

Table 4 - 100 year Storm Event

Duration	Intensity (in/hr)	Depth (in)
5 min	7.24	0.60
10 min	5.60	0.93
15 min	4.61	1.15
30 min	3.04	1.52
60 min	1.83	1.83
2 hr	1.03	2.05
3 hr	0.74	2.21
6 hr	0.42	2.53
24 hr	0.15	3.48

7.2 Storm Duration

7.2.1 Hydrograph

i. Runoff hydrographs from storm durations of 3 hour, 6 hour, and 24 hour durations for the 100 year storm events should each be derived and routed through the detention basin to ensure that the storm detention basin will perform properly under all conditions.

ii. The Farmer-Fletcher type of storm Distribution should be used. See Appendix A.

7.3 Release Rate

7.3.1 Maximum Peak Release Rate must not exceed 0.20 cubic feet per second per acre of development (cfs/acre)

7.3.2. City Engineer has the authority to restrict the release rate to less than the 0.20 cubic feet per second per acre (cfs/acre) as needed to meet changing or unusual needs or conditions.

7.3.3. Developer may choose the option to temporarily release detained storm water to existing irrigation ditches, sloughs and canals. If this option is selected the following must be met:

i. The release rate is to be restricted to 0.10 cubic feet per second per acre (cfs/acre). This is to avoid impacts to existing drainage facilities and downstream upsizing of utilities or natural drainages. This restriction must be approved by the City Engineer.

ii. The Developer is responsible to prepare a storm water model and routing that justifies that the restricted release rate avoids impacts to existing drainage facilities and downstream upsizing of utilities or natural drainages.

iii. The Developer must obtain approvals from any Federal, State agency, or any irrigation company that has jurisdiction over the proposed existing drainage facility.

iv. The City Attorney may require for sole-service irrigation facilities, that the developer obtain full indemnification and acknowledgement from each property owner for which the proposed existing drainage crosses their property and from each water rights owner for which a water right is diverted from the existing drainage facility below the point of storm water discharge. This acknowledgement must (a) recognize that storm water will be discharged to the existing drainage facility, (b) recognize that while this discharged storm water meets established State of Utah Standards for water quality for beneficial use, it may still contain soluble pollutants and other pollutants which make it through the treatment schemes, (c) recognize that while the peak historic storm flows will not be exceeded in the existing drainage facility, the frequency of the storm discharge to the existing facility will increase.

7.3.4 Developer may choose the option to temporarily retain storm water on-site until a downstream connection is available. If this option is selected the following must be met:

i. Approval from the City Engineer is required to allow for temporary retention.

ii. All pond requirements detailed in Section C subheading 2.0, Pond Requirements, must be installed, including the future outfall piping.

iii. The Developer is responsible to prepare a storm water model and routing that justifies that the future release rate avoids impacts to existing drainage facilities and downstream upsizing of utilities or natural drainages.

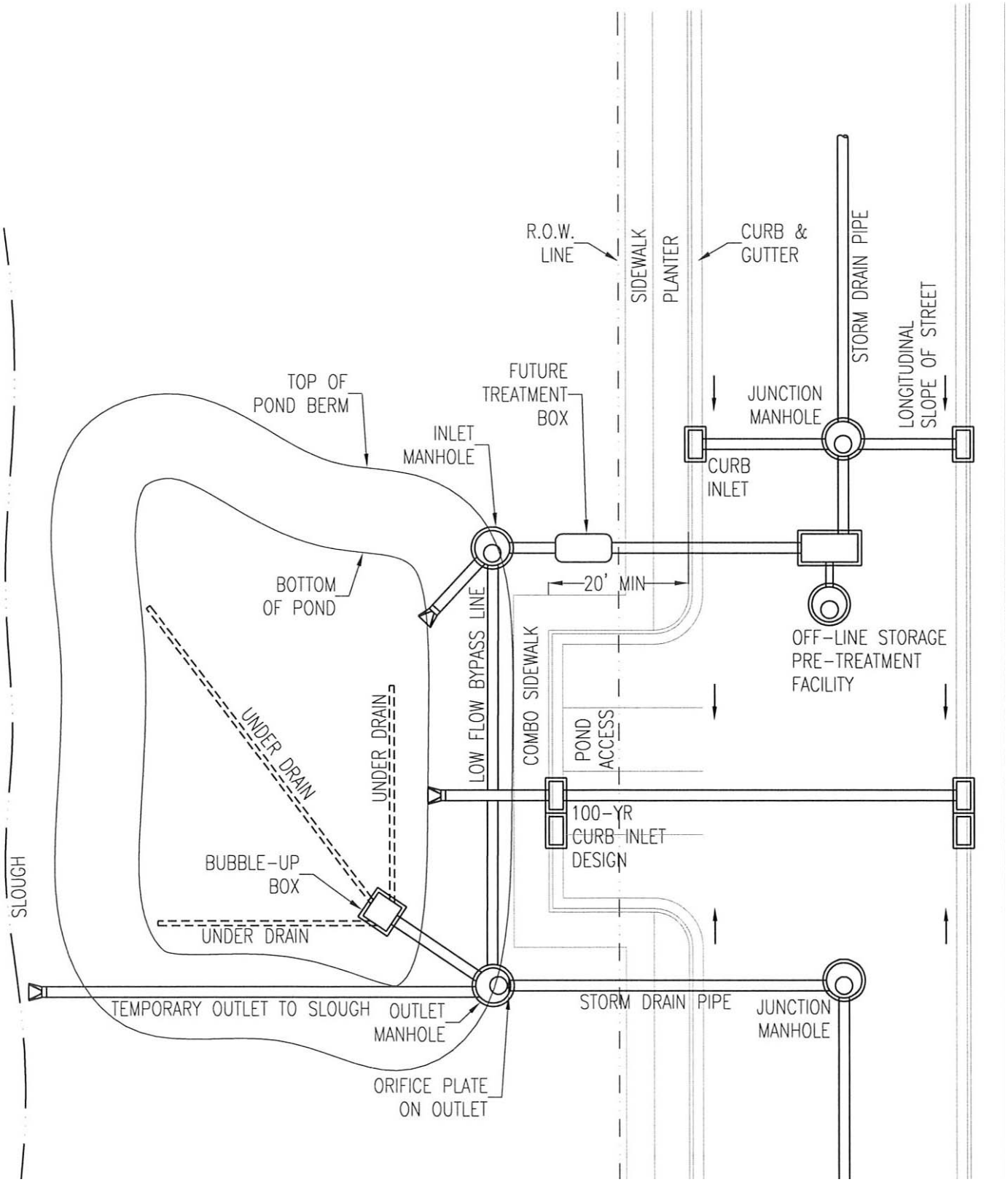
8.0 Pond Requirements

8.1 Refer to Figure 5, Standard Typical Pond Drawing, for basic pond requirements and layout.

a. The maximum allowable depth of water in the basin is 3 feet.
b. The allowable embankment side slopes shall be no steeper than 3:1 and less steep slopes are encouraged.
c. No part of the pond bottom of a landscaped detention basin may have a slope flatter than 0.50%
d. Basins are to be designed such that when runoff exceeds design values or when restrictions plug, excess storm water will be directed to the street system or other approved emergency spillway locations.
e. A back-up underdrain pipe collection system is to be designed for the pond in case of standing water problems.
f. A pretreatment structure is required as per the storm water quality requirements of Section D
g. A low flow piped connection between the pretreatment structure and the pond outlet structure shall be provided.
h. Site specific soil test holes may be required to determine groundwater depths related to pond construction as determined by the City Engineer.
i. Detention basin outlets should be designed to be non-plugging as much as possible. Outlet pipes should be protected by inlet grates which as sized, spaced, and oriented as to minimize plugging of the outlets.
j. Maintenance access to ponds should be provided. If pond outlet structures a placed a distance of more than 25 feet from the curb then a hard surface access should be provided to the outlet structure.
k. A water quality monitoring plan is to be submitted to the City Engineer for approval.

Figure 5

POND DETAILS



Section D Storm Water Quality Criteria

The types of pollutants which adversely affect the quality of storm water depend upon materials that are found on the surface within the tributary area that can be washed into the drainage system during storm events. It is anticipated that the primary pollutants that might affect the water quality of runoff in the American Fork area include oils and grease, sediment, pesticides, and floatables such as plastic and styrofoam. Since Utah Lake is the eventually receiving body of water, the quality of discharge of water is of significant importance. Each new development will be required to provide methods for removal of pollutants from their storm water prior to discharge to the American Fork City System.

9.0 Storm Water Treatment

Prior to discharging storm water, it must be treated to reduce illicit discharges of sediment, oils, floatables and other pollutants. The treatment method must be approved by the City Engineer.

9.1 Detention Pond Pretreatment Criteria

A Structural BMP for detention pond pretreatment is required for all storm water detention ponds. This pretreatment system must:

1. Be configured such that fine sediments and floatable pollutants are retained in an off-line structure to prevent resuspension.

2. Be capable of:
    - i. Separating both suspended solids and oils from stormwater at a rate no less than 80 percent removal efficiency at the maximum treatment flow rate.
    - ii. Settle out 100 percent of sand particles greater then the No 200 sieve size (0.075 mm) at the maximum treatment flow rate.
3. Be capable of having the storage manhole completely inspected and maintained from the top opening without obstruction.

4. Pass the peak flow rate without re-mixing or re-suspending the collected solids and oils.

5. Provide sediment storage areas for collected solids of a minimum of 75 cubic feet at a collection depth of 2 feet.

9.2 Design Storms

9.2.1 Storm Duration

a. Rational Method and SCS peak discharge method

The storm duration should be approximately equal to the computed time of concentration of the drainage.

b. Hydrograph Routing

The greatest runoff produced from the 1-hour, 2-hour, 3-hour, or 6-hour durations.

9.2.2 Maximum Treatment Flow Rate

a. Pretreatment System is to be able to convey the Maximum Treatment Flow Rate of the 2 year storm event.

Table 5 - 2 year Storm Event

Duration	Intensity (in/hr)	Depth (in)
5 min	1.80	0.15
10 min	1.32	0.22
15 min	1.12	0.28
30 min	0.76	0.38
60 min	0.47	0.47
2 hr	0.28	0.55
3 hr	0.21	0.63
6 hr	0.14	0.82
24 hr	0.05	1.18

9.2.3 Peak Flow

a. Pretreatment System is to be able to convey the Peak Flow Rate of the 25 year storm event.

Table 6 - 25 year Storm Event

Duration	Intensity (in/hr)	Depth (in)
5 min	3.84	0.32
10 min	2.94	0.49
15 min	2.48	0.62
30 min	1.72	0.86
60 min	1.09	1.09
2 hr	0.62	1.24
3 hr	0.45	1.35
6 hr	0.26	1.56
24 hr	0.10	2.40

9.3 Storm Water Quality Monitoring

The Developer shall submit to the City Engineer a Storm Water Quality Monitoring Plan. This plan shall contain at a minimum the following:

9.3.1 Baseline Water Quality

The Developer shall submit to the City Engineer two (2) analyzed samples of water collected from the existing drainage facility prior to construction. These samples must:

a. Be separated by two (2) weeks in sampling dates.
b. Be analyzed for the following by a reputable water quality testing laboratory for the following:

1. TDS concentrations - State water quality criteria for total dissolved solids (TDS) concentrations are no greater than: 2,000 mg/L for stock watering,
1,200 mg/L for irrigation
(Utah Administrative Code R317-2-14, June 01, 2006).

9.3.2 Durability Bond Period

The Developer shall submit to the City Engineer on at least a quarterly basis during the one (1) year durability bond period, analyzed samples of water collected, either during or immediately after a significant storm event, from the following points:

a. At the point of discharge from the pond. The sample shall be collected at the nearest point to the discharge end of the pond outlet pipe. If the pond outlet pipe is submerged then the sample shall be taken from the pond outlet box.

b. Approximately 20 feet downstream from the pond outlet pipe.

c. Be analyzed for the following by a reputable water quality testing laboratory for the following:

1. TDS concentrations - State water quality criteria for total dissolved solids (TDS) concentrations are no greater than: 2,000 mg/L for stock watering,
1,200 mg/L for irrigation
(Utah Administrative Code R317-2-14, June 01, 2006).

9.3.3 Review by City Engineer

a. The City Engineer may waive this storm water quality monitoring requirement is no downstream water rights are present in a given conveyance.

b. The City Engineer may require the following if the water quality standards are not met:
   1. Additional treatment measures are to be installed at the developers expense to bring the pond discharge into compliance
   2. Additional monitoring in both number of samples and length of time of sampling.

9.4 Erosion Control

American Fork City encourages the use of the following Best Management Practices on Construction Sites and Post Construction Site Storm Water Management Plans. BMP's with an asterisk are required to be a part of all Construction Site Storm Water Management Plans.

Best Management Practice	**BMP Code**
Benching	BE
* Contaminated or Erodible Surface Area	CESA
Chemical Mulch	CM
Compaction	CP
Erosion Control Blanket	ECB
Filter Strips	FS
Geotextiles and Mats	GM
Grassed Swales	GS
Hydromulching	HM
Slope Drain	SD
Temporary Drains and Swales	TDS
Temporary and Permanent Seeding	TPS

9.5 Sediment Control

American Fork City encourages the use of the following Best Management Practices on Construction Sites and Post Construction Site Storm Water Management Plans. BMP's with an asterisk are required to be a part of all Construction Site Storm Water Management Plans.

Best Management Practice	**BMP Code**
* Catch Basin Cleaning	CBC
Construction Road Stabilization	CR
Earth Berm Barrier	EB
Inlet Protection – Excavated	IPE
Inlet Protection – Gravel	IPG
Inlet Protection – Silt Fence or Straw Bale	IPS
Outlet Protection	OP
Rock Check Dams	RCD
Sediment Basin	SB
Street Cleaning	SC
* Stabilized Construction Entrance	SCE
* Storm Drain Flushing	SDF
Silt Fence	SF
Temporary Stream Crossing	TSC

The following practices are prohibited:

i. Piling soil or construction materials in street right of way
ii. Constructing soil bridges over curb and gutter.

9.6 Best Management Practices (BMPs) relative to quality and quantity of discharge to the storm drain system

American Fork City encourages the use of the following Best Management Practices on Construction Sites and Post Construction Site Storm Water Management Plans. BMP's with an asterisk are required to be a part of all Construction Site Storm Water Management Plans.

Best Management Practice	**BMP Code**
Conservation Easements	CE
Constructed Wetlands	CW
* Concrete Waste Management	CWM
* Detention / Infiltration Device Maintenance	DIDM
Extended Detention Basins	EDB
Hazardous Waste Management	HWM
In-Line Storage	ILS
Infiltration	IN
Minimizing Directly Connected Impervious Area	MDCIA
Open Space Design	OSD
Pest Control	PCS
* Portable Toilets	PT
* Spill Clean-up	SCU
Used Oil Recycling	UOR
Vehicle and Equipment Cleaning	VEC
Waste Disposal	WD
* Waste Handling and Disposal	WHD
Wet Ponds	WP