Original Date: May 3, 2006

Revision #1: May 17, 2006

Errata Sheet for
CFW Storm Water Management Design Manual

1. Page CFW-16, Table 2.1.4-2 – Runoff Coefficients
   Insert: **“Commercial/Industrial/House of Worship/School”** for line between lines 10 and 11 in body of table (before “4% Open Space”).

2. Page CFW-18, Section 2.1.5.2 – Application
   First line: Replace “greater than 100 acres” with **any size**.

3. Page CFW-23, Section 3.1.5 – Design Storm Recommendations
   Paragraph 1 – delete last line: **“Some exceptions may be allowed where an adequate overflow route is not possible.”**

   Sump Inlets, add next to last sentence: **“…the storm sewer outfall. If the upstream pipe already conveys more than Q25, then downstream pipe must have at least the same capacity from sump to outfall, and an inlet must still be installed at sump to allow for emergency overflow. In the event…”**

4. Page CFW-30, Section 3.2.4.2 – Inlets on Grade with Gutter Depression (Type CO-D)
   Line before “Example”: **…Figure 3.2.4-8…**

5. Page CFW-46, Section 3.2.8.13 – Storm Drain Design Example
   Column 18: **“This should be the greater of a substantial portion of Q5…”**

6. Page CFW-49, Section 3.3 – General Construction Standards
   Change title: **“Pipe Connections and Curved Alignment”**

   Inlets: **“Standard inlet depth is 4.5’ at the lead line and 4.0’ at the opposite end, with the bottom sloped to drain to the lead line.”**

   Streets: Add next to last sentence: **“…curb to the valley gutter. The minimum grade for any valley gutter shall be 0.50%. Where a crest or sag…”**

7. Page CFW-50, Section 3.4 – Easements for Closed Conduit Systems
   Second paragraph after table: **“For pipe sizes up through 54”, a minimum of five (5) additional feet shall be dedicated…”** [Rationalize: with 5’ required from edge of pipe to edge of easement, 1’ is not enough to share with other utilities.]

8. Page CFW-57, Section 4.5 “Storage Design”
   Replace items 3 and 4 and revise 5 and 9:

3. The Modified Rational Method is allowed for planning and conceptual design for watersheds of 200 acres and less. For final design purposes the Modified Rational Method is allowed only for watersheds of 25 acres and less (see Table 2.1.1-2).

4. Detention Basins draining watersheds over 25 acres shall be designed using a detailed unit hydrograph method acceptable to the City of Fort Worth. These include Snyder's Unit Hydrograph (>100 acres) and SCS Dimensionless Unit Hydrograph (any size). The SCS method is also allowed for basins with watersheds less than 25 acres (see Table 2.1.1-2).

5. Add sentence in at end of paragraph:
Analysis of additional storm (i.e. 5-year, 25-year, etc.) may be required where storm sewers are included in the watershed.

9. Add in **"fully urbanized"** and **"closed conduit portion"**
An emergency spillway shall be provided at the 100-year maximum storage elevation with sufficient capacity to convey the **fully urbanized** 100-year storm assuming blockage of the **closed conduit portion** outlet works with six inches of freeboard. Spillway requirements must also meet all appropriate state and Federal criteria.

9. Page CFW-59, Examples of Open Channel Transition Structures
   Reword 1st sentence to read:
   See drawings in Miscellaneous Details and Specifications and application guidance for Harris County Flood Control District Straight Drop Structure, Bureau of Reclamation Baffled Chute (Basin IX) and Gabion Drop Structure.

10. Page CFW-73 – Engineer's Checklist for Final Storm Water Management Plan
    Add in as item – **C. Digital copy of final hydrologic and hydraulic models**
    Add in "and C":
    5.   Hydrologic Analysis and Storm Water Management Design Plan (separate Attachment, either A or B and C)

11. Page CFW-31 and CFW-32, Description of Columns in Figure 3.2.4-8
    Replace with attached pages.

12. Page CFW-36, Figure 3.2.4-8
    Replace with attached table.

13. Page CFW-45, Figure 3.2.8-5
    Replace with attached table.

14. Page CFW-85, City of Fort Worth, Miscellaneous Details and Specifications
    Add attached, **Section 9.2.1 General Design Criteria** at bottom of this page.

Table Column Description:

Column 1	Design Point for Inlet
Column 2	Inlet number(s)
Column 3	Location of inlet by storm drain station number
Column 4	Drainage area designation for incremental area
Column 5	Drainage area size (acres)
Column 6	Runoff coefficient “c”
Column 7	Time of concentration (minutes)
Column 8	**Slope of approach gutter (S_0) (ft/ft)**
Column 9	**Street crown section type (straight crown [“rooftop”] or parabolic)**
Column 10	**Reciprocal of the pavement cross slope for pavements with straight crown slopes, $1/\theta_0$**
Column 11	**Rooftop crown slope “z” (ft/ft)**
Column 12	**Manning’s roughness coefficient (n) for pavement**
Column **13**	5-year rainfall intensity (in/hr)
Column **14**	5-year runoff, Q=cAi (cfs)
Column **15**	5-year carryover flow from upstream inlet (cfs)
Column **16**	5-year total gutter flow **(Column 14 + Column 15)** (cfs)
Column **17**	Total street capacity to top of curb (cfs)
Column **18**	100-year rainfall intensity (in/hr)
Column **19**	100-year runoff, Q=cAi (cfs)
Column **20**	100-year carryover flow from upstream inlet (cfs)
Column **21**	100-year total gutter flow **(Column 17 + Column 18)** (cfs)
Column **22**	Total right-of-way capacity (normally 2.5” over top of curb) (cfs)
Column **23**	This indicates the controlling storm for inlet spacing, depending on which criteria (5-year in street or 100-year in ROW) may be exceeded. This indicates whether the inlet is sized for the 5-year or 100-year flows.
Column **24**	Depth of gutter flow "yo" in approach gutter from spread of water determinations in *i*SWM Figure 3.2-2 or from direct solution of Manning's equation for triangular gutters: $yo = 1.245\ Qo^{3/8}\ (n^{3/8}/So^{3/16})\ (1/z)^{3/8}$. When the crown is overtopped, a composite analysis will be required.
Column **25**	Spread of water (Sp) or width of ponding in the gutter measured from the face of curb. **Column 19 times column 24**, or the distance from the gutter to the crown, if the crown height is exceeded.
Column **26**	Discharge in cubic feet per second (Q) which wilt be intercepted by an inlet one foot in length for a given depth of flow in the approach gutter (Yo). Determined from Figure 3.2.4-6 or from the following equation: **$Q_0/L_0 = [0.7/ (H1-H2)]\ [(H1)^{5/2} - (H2)^{5/2}]$**
Column **27**	Length of inlet (Lo) in feet which is necessary to intercept a given discharge Qo. **Column 16 or 21 divided by Column 24.**
Column **28**	Actual length (L) in feet of inlet which is to be provided (10’, 15’ or 20’)
Column **29**	Ratio of the length of inlet provided (L) to the length of the inlet required for 100% interception (Lo). **Column 27 divided by Column 26.**

Column **30** Ratio of discharge intercepted by the inlet in question determined from Figure 3.2.4-7 using the values determined in **Column 28 and Column 24.**

Column **31** Discharge (Q) in cubic feet per second which the inlet in question actually intercepts in the design storm. **Column 16 or 21 times Column 30.**

Column **32** Carry-over flow (q) is the amount of water which passes the inlet in a **5-year storm. A substantial portion of the 5-year flow should be picked up by the inlet. The carry-over flow should be accounted for in further downstream inlets.**

Column 33 **Carry-over flow (q) is the amount of water which passes the inlet in a 100-year storm. The carry-over flow should be accounted for in further downstream inlets and should be reflected in the inlet bypass flow (Column 17) in the Storm Drain Hydraulics Table (minor variances may occur due to travel time routing in the Hydraulics Table).**

COMPUTATION SHEET
FOR DETERMINING CAPACITY OF
CURB OPENING LET ON GRADE (DEPRESSED)

Inlet			Drainage Area				"So" Street	Street	F/F Pavement	Rooftop	Manning's coefficient			5-year	5-year				100-year	100-year	Right-		Depth		Pickup	Length	Length				5-year	100-year	
Design Point	Inlet No.	Station	Area No.	Area (acres)	Runoff "c"	Conc. Time (min)	Long. Slope (ft/ft)	Section (type)	Width (ft)	Crown Slope "Z" (ft/ft)	for pavement "n"	5-year Intensity (in/hr)	5-year Runoff (cfs)	Carryover Flow (cfs)	Total Gutter Q (cfs)	Street Capacity (cfs)	100-year Intensity (in/hr)	100-year Runoff (cfs)	Carryover Flow (cfs)	Total Gutter Q (cfs)	of-Way Capacity (cfs)	Design Storm*	of Flow "Yo"** (ft)	Spread of Flow (Sp) (ft)	Per Foot Qo/Lo (cfs/ft)	Required Lo (ft)	Provided L (ft)	L/Lo	Q/Qo	Inlet Capacity (cfs)	Carryover Flow "q" (cfs)	Carryover Flow "q" (cfs)	Comments
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
1	1	B 5+98	B1/2	3.2	0.65	15	0.01	ROOFTOP	28	0.02	0.019	4.86	10.11	0	10.11	141.665	7.98	16.60	0	16.60	80	5-year	0.35	14	0.79	12.80	15	1.17	1	10.11	0.00	6.49	Assume 5-year pick-up in 100-year storm
	2		B1/2	3.2	0.65	15	0.01	ROOFTOP	28	0.02	0.019	4.86	10.11	0	10.11		7.98	16.60	0	16.60	80	5-year	0.35	14	0.79	12.80	15	1.17	1	10.11	0.00	6.49	Assume 5-year pick-up in 100-year storm
2	3	B 4+50	B2/2	2.6	0.65	15	0.005	ROOFTOP	28	0.02	0.019	4.86	8.21	0	8.21	40	7.98	13.49	6.49	19.98	60	5-year	0.38	14	0.83	9.90	10	1.01	1	8.21	0.00	11.76	Assume 5-year pick-up in 100-year storm
	4		B2/2	2.6	0.65	15	0.005	ROOFTOP	28	0.02	0.019	4.86	8.21	0	8.21	40	7.98	13.49	6.49	19.98	60	5-year	0.38	14	0.83	9.90	10	1.01	1	8.21	0.00	11.76	Assume 5-year pick-up in 100-year storm

Notes: * This is the controlling storm for inlet spacing, depending on which criteria (5-year in street or 100-year in ROW) may be exceeded.
** Assumption of full curb in all conditions may lead to overestimation of inlet capacity.

$Q = [0.56/n]\ S_x^{5/3}\ S^{1/2}\ T^{8/3}$

COMPUTATION SHEET
HYDRAULIC COMPUTATIONS FOR STORM DRAINS

STORM DRAIN HYDRAULIC CALCULATIONS TABLE

FROM	TO	Pipe	Drainage Area			Runoff	Incr.	Total	Time of Concentration			5-year	100-year	Q5	Q100	Inlet	Q	Pipe			HGL		HEAD LOSS CALCULATIONS							Design	Invert Elev.		T/C	
		Length	Incremental		Total	"c"	cA	cA	Inlet	Travel	Total	Intensity	Intensity	Runoff	Runoff	bypass	pipe	Size	n	Sf	D/S	U/S	V1 (in)	V2 (out)	$V1^2/2G$	$V2^2/2G$	Kj	$KjV1^2/2G$	Hk	HGL	FROM	TO	ELEV.	
		feet	No.	Area	Area				min.	min.	min.	in/hr.	in/hr.	cfs	cfs	cfs	cfs	in.		ft/ft	Elev.	Elev.	ft/sec	ft/sec	ft.	ft.		ft.	ft.	Elev.	ft.	ft.	ft.	COMMENTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
LINE A																																		
4+00	5+42	142	A1	35.00	35.00	0.65	22.75	22.75	15.00		15.00	4.86	7.98	110.57	181.55	14.50	167.05	48	0.013	0.0135	818.17	820.09	13.29	13.29	2.74	2.74	0.00	0.00	0.00	820.09	813.16	816.00	822.50	A1=future phases
1+86	4+00	214	A2	0.50	35.50	0.65		23.08	15.00	0.18	15.18	4.86	7.98	112.14	184.14	11.80	172.34	54	0.013	0.0077	816.08	817.72	13.29	10.84	2.74	1.82	0.50	1.37	0.45	818.17	811.02	813.16	819.50	
1+43	1+86	43	A3	0.18	35.68	0.65	0.12	23.19	15.00	0.51	15.51	4.86	7.98	112.71	185.07	0.00	185.07	54	0.013	0.0089	814.96	815.34	10.84	11.64	1.82	2.10	0.75	1.37	0.74	816.08	809.59	810.52	818.00	
0+50	1+43	93	A4	0.56	36.24	0.65	0.36	23.56	15.00	0.57	15.57	4.86	7.98	114.48	187.98	0.00	187.98	60	0.013	0.0052	814.10	814.59	11.64	9.57	2.10	1.42	0.50	1.05	0.37	814.96	808.53	809.09	817.78	min Hk = 0.10'
0+00	0+50	50			36.24	0.65		23.56	15.00	0.57	15.57	4.86	7.98	114.48	187.98	0.00	187.98	60	0.013	0.0075	813.23	813.61	9.57	9.57	1.42	1.42	0.35	0.00	0.50	814.10	808.23	808.53	---	45° BEND
LINE A-2																																		
A 1+86	n. inlet	22	see note	0.25	0.25	0.65	0.09	0.16	15.00		15.00	4.86	7.98	1.24	2.65	0.00	2.65	21	0.013	0.0003	818.17	818.18	0.00	1.10	0.00	0.02	1.25	0.00	0.02	818.20	812.02	815.00	819.50	half A1 bypass + half A2
A 1+86	s. inlet	24	see note	0.25	0.25	0.65	0.09	0.16	15.00		15.00	4.86	7.98	1.24	2.65	0.00	2.65	21	0.013	0.0003	818.17	818.18	0.00	1.10	0.00	0.02	1.25	0.00	0.02	818.20	812.02	815.00	819.50	half A1 bypass + half A2
LINE A-3																																		
A 1+86	n. inlet	22	see note	0.18	0.18	0.65	0.09	0.12	15.00		15.00	4.86	7.98	9.28	14.08	0.00	14.08	21	0.013	0.0079	816.08	816.25	0.00	5.86	0.00	0.53	1.25	0.00	0.67	816.91	811.52	813.50	818.00	half (A1+A2 bypass) + half A3
A 1+86	s. inlet	24	see note	0.18	0.18	0.65	0.09	0.12	15.00		15.00	4.86	7.98	9.28	14.08	0.00	14.08	21	0.013	0.0079	816.08	816.27	0.00	5.86	0.00	0.53	1.25	0.00	0.67	816.93	811.52	813.50	818.00	half (A1+A2 bypass) + half A3
LINE A-4																																		
0+20	s. inlet	18	A4/2	0.28	0.28	0.65	0.18	0.18	15.00		15.00	4.86	7.98	0.88	1.45	0.00	1.45	21	0.013	0.0001	814.97	814.97	0.00	0.60	0.00	0.01	1.25	0.00	0.01	814.98	811.67	813.07	817.57	
0+20	0+37	17	A4/2	0.28	0.28	0.65	0.18	0.18	15.00		15.00	4.86	7.98	0.88	1.45	0.00	1.45	21	0.013	0.0001	814.97	814.97	0.00	0.60	0.00	0.01	1.25	0.00	0.01	814.98	811.67	813.07	817.57	north inlet
0+00	0+20	20			0.56	0.65	0.00	0.36	15.00		15.00	4.86	7.98	1.77	2.90	0.00	2.90	24	0.013	0.0002	814.96	814.96	0.60	0.92	0.01	0.01	0.75	0.00	0.01	814.97	810.22	811.42	817.78	
LINE B																																		
5+98	6+15	17	B1/2	3.20	3.20	0.65	2.08	2.08	15.00		15.00	4.86	7.98	10.11	16.60	6.49	10.11	21	0.013	0.0041	817.70	817.77	0.00	4.20	0.00	0.27	1.25	0.00	0.34	818.12	814.73	815.04	819.54	west inlet
4+50	5+98	148	B1/2	3.20	6.40	0.65	2.08	4.16	15.00	0.07	15.07	4.86	7.98	20.22	33.20	12.98	20.22	24	0.013	0.0080	816.02	817.20	4.20	6.44	0.27	0.64	0.50	0.14	0.51	817.70	813.00	814.48	819.48	
2+15	4+50	235	B2	5.20	11.60	0.65	3.38	7.54	15.00	0.45	15.45	4.86	7.98	36.64	60.17	23.53	36.64	30	0.013	0.0080	813.76	815.63	6.44	7.46	0.64	0.87	0.75	0.48	0.38	816.02	810.15	812.50	818.00	
0+50	2+15	165	B3	2.50	14.10	0.65	1.63	9.17	15.00	0.98	15.98	4.86	7.98	44.54	73.14	20.00	53.14	36	0.013	0.0063	812.27	813.31	7.46	7.52	0.87	0.88	0.50	0.43	0.44	813.76	808.00	809.65	815.65	
0+00	0+50	50	B4	1.80	15.90	0.65	1.17	10.34	15.00	1.34	16.34	4.86	7.98	50.23	82.47	0.00	82.47	48	0.013	0.0075	811.53	811.91	7.52	6.56	0.88	0.67	0.35	0.31	0.36	812.27	805.00	807.00	814.00	channel HGL=811.53
LINE B-1A																																		
B 5+98	n. inlet	17	B1/2	3.20	3.20	0.65	2.08	2.08	15.00		15.00	4.86	7.98	10.11	16.60	6.49	10.11	21	0.013	0.0041	817.70	817.77	0.00	4.20	0.00	0.27	1.25	0.00	0.34	818.12	814.73	815.04	819.54	east inlet
LINE B-2 A&B																																		
B 4+50	e. inlet	18	B2/2	2.60	2.60	0.65	1.69	1.69	15.00		15.00	4.86	7.98	13.11	19.98	11.77	8.21	21	0.013	0.0027	816.02	816.07	0.00	3.41	0.00	0.18	1.25	0.00	0.23	816.29	812.50	813.50	818.00	includes B1 bypass
B 4+50	w. inlet	18	B2/2	2.60	2.60	0.65	1.69	1.69	15.00		15.00	4.86	7.98	13.11	19.98	11.77	8.21	21	0.013	0.0027	816.02	816.07	0.00	3.41	0.00	0.18	1.25	0.00	0.23	816.29	812.50	813.50	818.00	includes B1 bypass
LINE B-3 A&B																																		
B 2+15	e. inlet	18	B3/2	1.25	1.25	0.65	0.81	0.81	15.00		15.00	4.86	7.98	10.97	18.25	10.00	8.25	21	0.013	0.0027	813.76	813.81	0.00	3.43	0.00	0.18	1.25	0.00	0.23	814.04	810.65	811.15	815.65	includes B2 bypass
B 2+15	w. inlet	18	B3/2	1.25	1.25	0.65	0.81	0.81	15.00		15.00	4.86	7.98	10.97	18.25	10.00	8.25	21	0.013	0.0027	813.76	813.81	0.00	3.43	0.00	0.18	1.25	0.00	0.23	814.04	810.65	811.15	815.65	includes B2 bypass
LINE B-4																																		
0+20	w. inlet	18	B4/2	0.90	0.90	0.65	0.59	0.59	15.00	0.00	15.00	4.86	7.98	2.84	14.67	0.00	14.67	24	0.013	0.0042	812.44	812.51	0.00	4.67	0.00	0.34	1.25	0.00	0.42	812.94	808.65	809.50	814.00	includes B3 bypass
0+20	0+38	18	B4/2	0.90	0.90	0.65	0.59	0.59	15.00	0.00	15.00	4.86	7.98	2.84	14.67	0.00	14.67	24	0.013	0.0042	812.44	812.51	0.00	4.67	0.00	0.34	1.25	0.00	0.42	812.94	808.65	809.50	814.00	east inlet; B3 bypass
0+00	0+20	15			1.80	0.65	0.00	1.17	15.00	0.00	15.00	4.86	7.98	5.69	29.34	0.00	29.34	33	0.013	0.0031	812.27	812.31	4.67	4.94	0.34	0.38	0.75	0.25	0.12	812.44	807.00	807.90	814.00	

Notes:
1 Time of concentration (and intensity) only changes at downstream junctions. Paired inlets do not constitute a downstream junction.
2 HGL must be below grade along main or at least 1' below top of curb at each inlet (including entry loss of 1.25v2/2g).
3 Inlet spacing shall be determined by 5-year to top of curb or 100-year filling right-of-way, whichever is most restrictive.
4 Minimum head loss shall be 0.10 feet in a subcritical flow regime. Supercritical flow regimes do not generate head losses.

9.3 Straight Drop Spillways

Overview
9.3.1

The three parts of a straight drop spillway (see Exhibit 9-1) are:

- Upstream draw down reach
- Drop opening
- Downstream hydraulic jump reach

The drop is usually constructed of steel sheet piling. Reinforced concrete lining and riprap are placed upstream and downstream of the drop structure for erosion and scour protection.

Design Criteria
9.3.2

Design criteria for straight drop spillways are:

- Comply with general design criteria for all transition control structures in Section 9.2.1, General Design Criteria.
- Design steel sheet piling to prevent bending or rotating.
- Coat steel sheet piling in accordance with industry standards to reduce rusting and scaling.
- Use concrete lining on the entire cross-section upstream and downstream of the drop.
- Tie the concrete lining to the steel sheet piling drop structure.
- Use a minimum 6-inch thick slab on the downstream concrete lining due to the impact load and potential sever turbulence.
- Determine length of concrete lining upstream and downstream of the drop.
- Include 20 feet of riprap at the ends of the concrete slope paving to decrease flow velocities and protect the concrete toe from scour (see Section 4.4.8 Stone Riprap Design)

General Design Criteria

9.2.1

General design criteria for transition control structures are:

- **Design for a range of flows and tailwater conditions up to and including the 1% exceedance event.**
- **Conduct a geotechnical investigation to assist with design of the structure.**
- **Locate transition control structures where flow is straight. Avoid channel bends and high turbulence areas, if possible.**
- **Provide structural erosion protection where maximum velocities are exceeded upstream and downstream of the transition control structure and where the hydraulic jump occurs.**
- **For drop structures in lateral channels at the confluence with the receiving channel:**
    - **Locate the drop just inside the ultimate right-of-way of the receiving channel.**
    - **Design the hydraulic jump to occur before it enters the receiving channel.**